JANUARY 1961
In Two Sections
Section I

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ILLUMINATING ENGINEERING

Journal of the
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For silent lighting installations in schools, hospitals, libraries and other critical areas where absence of noise is the primary consideration, specify ADVANCE **"A"** QUIET-RATED fluorescent lamp ballasts. Catalog No. RQM-2S40 for 118 V. operation. Catalog No. VQM-2S40 for 277 V. operation.

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"We expect these diffusers cast of Du Pont MONOCITE* to keep their beauty for the life of the fixtures"

Lighting shield panels made by
THE POLYCAST CORP.
Stamford, Conn.

The Deering Milliken Building, 1045 Sixth Ave., New York City. Architects: Carson & Lundin, New York City. Fixture manufacturer: The Frink Corp., Brooklyn, N. Y. Installation: Eastern States Electrical Contractors, Inc., New York, N.Y.

POLYCHEMICALS DEPARTMENT

DU PONT

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Says Roy Duncan, superintendent of New York's new Deering Milliken Building. "The assignment was to get the 'most exciting ceiling in New York' for our first three floors. So the architects designed the checkerboard layout and specified diffusers that are cast from Du Pont MONOCITE.

"These panels were selected because they diffuse the light perfectly, maintaining maximum efficiency for years. They disguise the presence of fluorescent tubes and can be used in larger areas than other types.

"Also, they're extremely durable and easily cleaned, which keeps our maintenance problems at a minimum. We expect these diffusers**, cast by The Polycast Corp. of Stamford, Conn., to last the life of the fixtures. It's obvious why we recommend them highly."

It will pay you to find out how Du Pont's customers are using Du Pont MONOCITE to produce lighting-fixture shields that will give you outstanding service with a minimum of maintenance. For more information, write: E. I. du Pont de Nemours & Co. (Inc.), Dept. IE-1, Room 2507M, Nemours Bldg., Wilmington 98, Delaware.

Trademark for Du Pont's methacrylate monomer

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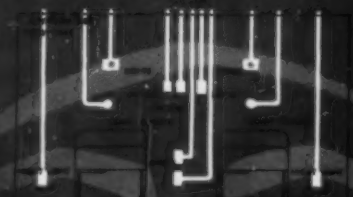
Centron-10 means a pleasant recuperative environment

In one centralized system, Centron-10 incorporates up to ten hospital bedroom services normally installed separately. This means more comfort to the patient and more convenience to the hospital staff.



"OLDWAY"— Up to 22 service outlets clutter the walls of two adjoining rooms. Various fixtures and accessory equipment must then be separately ordered and installed.

"CENTRON-10 WAY" — Requires only 8 service lines for back-to-back installation. All auxiliary equipment may be consolidated into the one neat console. No separate fixtures need be ordered.

Centron-10

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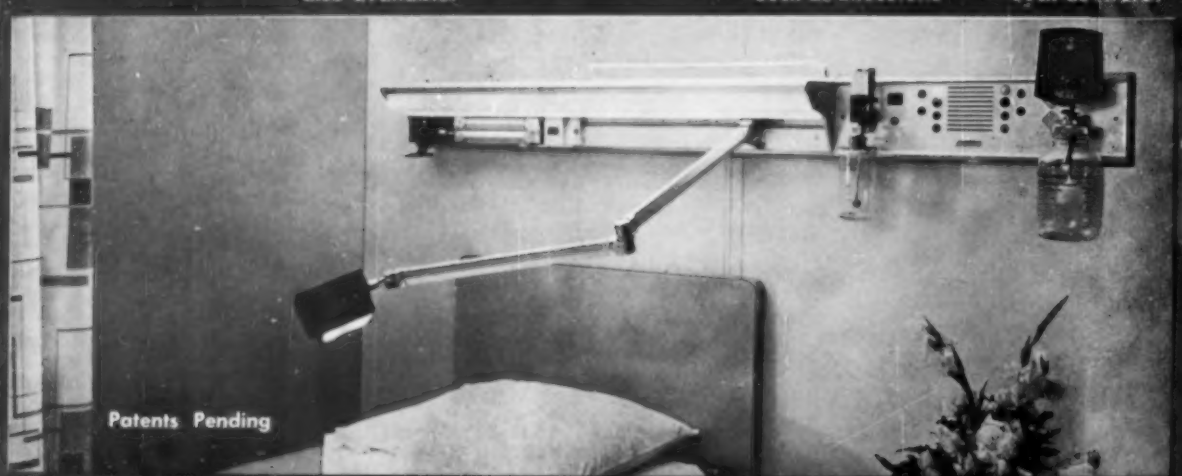
***Such as Executone **Such as N.C.G.**



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ILLUMINATING ENGINEERING

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

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Section 1

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How Day-Brite lighting helps a school prepare for tomorrow

The "little red school house" was fine in its day, but future demands on our educational system require a new kind of educational plant. This high school, incorporating some of today's most forward-looking architectural concepts, promises to remain modern and efficient for years to come.

With great attention given to both form and function throughout, Day-Brite was the logical lighting choice. Semester after semester after semester, these fixtures will provide highest visual comfort with substantial long-range operating and maintenance economies.

If a school building or remodeling project figures in your "tomorrow", consult your Day-Brite representative about the lighting designed with "tomorrow" in mind. *Day-Brite Lighting, Inc., 6260 N. Broadway, St. Louis 15, Mo. and Santa Clara, Calif. In Canada: Amalgamated Electric Corp., Ltd., Toronto 6, Ont.*

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NATION'S LARGEST MANUFACTURER OF
COMMERCIAL AND INDUSTRIAL LIGHTING EQUIPMENT

Superb Day-Brite Holiday fixtures maintain a minimum lighting level of 70 footcandles.

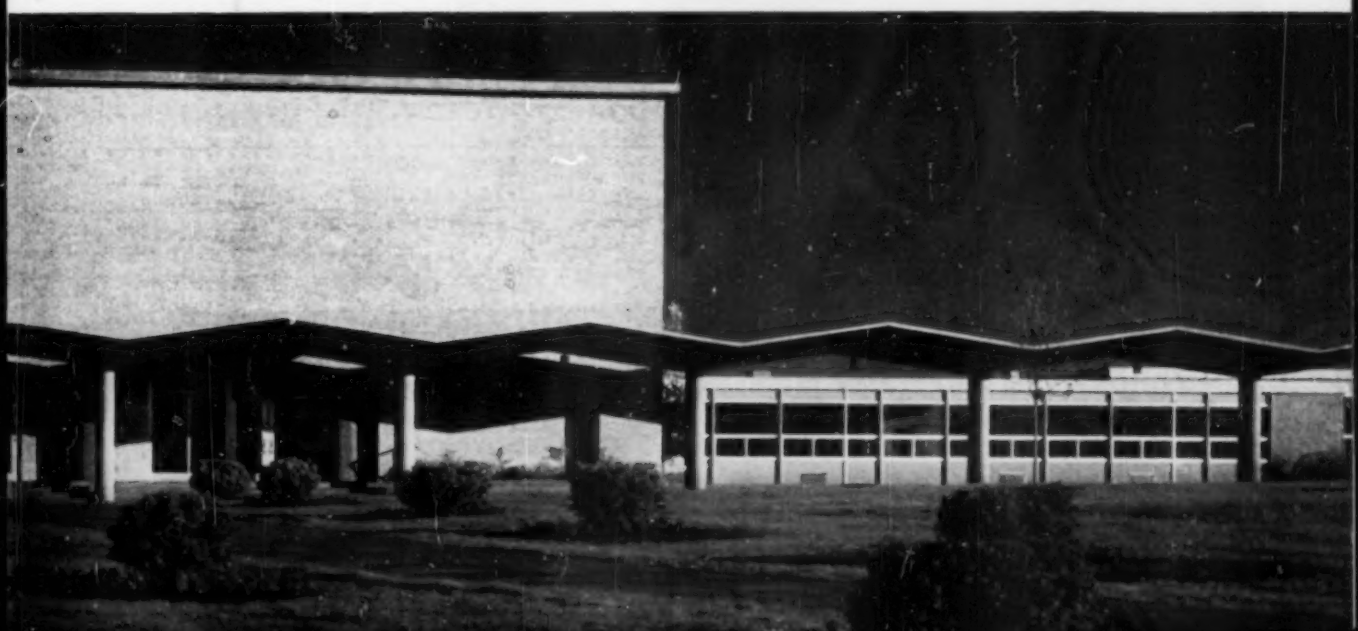
Princeton High School,
outside of Cincinnati

Architect:
Potter, Tyler, Martin and Roth

Consulting Engineer:
Fosdick and Hilmer

Electrical Contractor:
Beltzhoover Electric Co.

Molded acrylic plastic enclosures control light prismatically, eliminating glare.



Litecontrol Lighting Helps You See

This is an Award-Winner!

INSTALLATION: Concord-Carlisle High School, Concord, Massachusetts

ARCHITECT: Warren H. Ashley, Hartford, Conn.

ELECTRICAL ENGINEER: Fred Dubin Associates, Hartford, Conn.

ELECTRICAL CONTRACTOR: Delta Electric Service, Boston, Mass.

DISTRIBUTOR: General Electric Supply Company, Boston, Massachusetts

AREA SHOWN: Classroom

FIXTURES: Litecontrol #4628SL and 4624RS, pendant mounted baffle fixtures, on 277 volt operation

CEILING HEIGHT: Approximately 10'-6"

INTENSITY: 50 Footcandles average in service

Winner of a citation for the architect from "School Executive" Magazine, this new, campus type high school is worthy of a second look on many counts — including the lighting. The basic functional fixture design provides every lighting need of this modern school — intensity at today's levels, visual comfort and economy.

The pendant mounted baffle fixtures feature an open top to increase ceiling illumination and facilitate servicing. This type fixture stays cleaner longer and lamps can be changed or cleaned from above. Shielding angle is 45° crosswise. Durable, high quality white enamel provides 89% reflectance.

Litecontrol 4628SL and 4624RS are easy to install, have only 2 parts, no extra parts to assemble.

These fixtures do a functional job for young eyes at this school and for any school where you specify or install them.

LITECONTROL

Fixtures

KEEP UPKEEP DOWN

LITECONTROL CORPORATION,

36 Pleasant Street, Watertown 72, Massachusetts

DESIGNERS, ENGINEERS AND MANUFACTURERS OF FLUORESCENT LIGHTING EQUIPMENT DISTRIBUTED ONLY THROUGH ACCREDITED WHOLESALERS

Urgency No. 1—

RELIGHTING

Chances are that relighting may bring current recommended levels to more people than new lighting. Put a light meter to many of the mushrooming new buildings, gorgeous though they may be, and the reading may show 60 to 80 footcandles in a brand new office. Somewhere along the line these buildings have counted on their spectacular newness to attract tenants and/or customers, and have not accepted the functional levels of current recommendations. In a few short years, no doubt, they will be the lighting man's relighting problem.

Meanwhile, however, many existing areas are surpassing their imposing new neighbors. Their purpose is entirely a practical one. Upon renewal—of decor and/or lighting, or both—may hinge their commercial survival.

Renewal, of course, involves more than simple replacement of existing equipment. Successful redesign of a lighting system often requires the highest order of illuminating engineering and architect-engineer teamwork. Relighting jobs on this and the following nine pages are typical of this advanced skill.

Relighting Satisfies Science and Sentiment

Even a sentimental attachment to an archaic building cannot confound the progress of science when modern equipment and engineering skill can successfully convert a *circa* 1892 horseshoe calk factory into executive offices with lighting levels upwards of 120 footcandles. The 1892 building of the Neverslip Horseshoe Calk (*Calk: a tapered metal piece projecting downward on the shoe of a horse or ox to prevent slipping—Webster*) Manufacturing Co., of historical significance to the Johnson and Johnson Co. management, was chosen as the new home for the company's Hospital and Dental Division. A complete modernization program, within the shell of the old building, was charged with making the area suitable for executive use.

Built in the 19th Century mill style with wooden beams and brick walls, the building had nary a straight wall, square corner or flat ceiling area. The ceiling, part wood and part tin, was in such poor condition that concealment was imperative, yet the standard luminous ceiling installation would have involved such extensive cutting and patching around obstructions that costs were prohibitive. The addition of exposed ducts for air conditioning meant that light sources would have had to be hung on the underside of the ducts in a luminous ceiling, removing all possibilities for maintaining even ceiling brightness. Furthermore, maintenance of ceiling-mounted sources would have required removal of entire sections of diffusers.

Solution was a modular treatment using large suspended fixtures which created a rug-sized "ceiling" composed of lamp channels alternated with egg-crate plastic louver panels. High-output, 800-ma white fluorescent lamps, mounted at the new

First place ALC entry by A. S. Robinson, New Jersey Section.
Modular treatment using standard, large, suspended fixtures provides benefits of luminous ceiling while surmounting the problem of innumerable obstructions.

"ceiling" line, direct two-thirds of their output upward, creating an indirect lighting environment. Shadows from the ceiling obstructions are thrown on the real ceiling instead of on the diffusers below. With the entire system suspended below the ceiling, light sources can be placed in optimum engineering positions, without concern for the location of beams, pipes, or ducts. Lamp and ballast maintenance is at the lowered ceiling line and large diffusers are removed only for cleaning.

Obviating the problem of obsolescence, a simple change to 1500-ma lamps and ballasts, with no rewiring or mechanical difficulties, will double the lighting levels available from the system. From the decorative angle, a choice of five louver colors permits coordination of the lighting units with the decorative schemes of the individual offices.

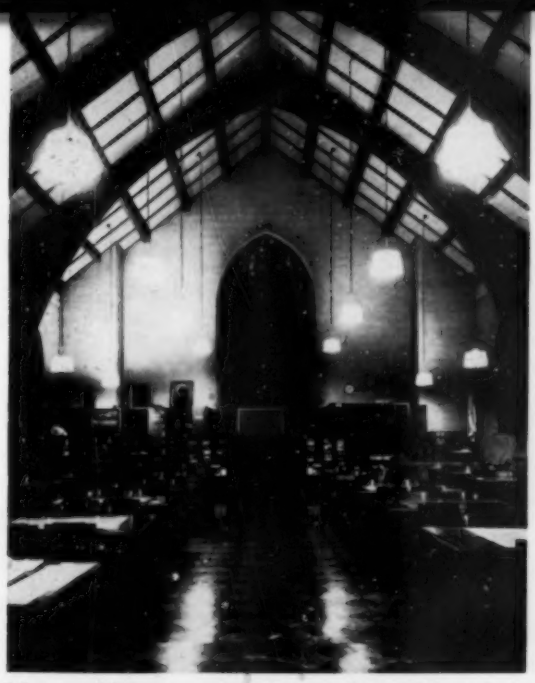
Lighting levels range from 120 to 180 footcandles in the 22 offices, depending upon the size of the office and reflection factors. Despite the structural complications, costs were kept to a minimum, since only a few minor modifications of the hanging assembly and layout were required to fit the standard fixtures to the individualized building.

Minimum Alterations—Maximum Lighting

Look what relighting did for Cathedral Prep School in Erie, Pa. None of the alterations is major—except the seeing result.

Chemistry Classroom—*Before* photo challenges engraving art to reproduce scene under 7 glarey footcandles.

***After* (right), 65 to 70 footcandles in the classroom from suspended, two-lamp, fluorescent luminaires.**



Library—*Before*, suspended glare balls deliver 8 fc along with dark shadows and hot spots. *After* (right), without detracting from architectural details, suspended rows of luminaires with 1500-ma high-output lamps provide a comfortable 100 to 110 fc maintained.

Gymnasium—*Before*, 10 footcandles on the playing area; spectator area defies the meter.

Gymnasium—*After*, 65 to 70 footcandles from suspended, two-lamp luminaires.

Photos and data courtesy Day-Brite Lighting, Inc., St. Louis, Mo.

◄ AFTER, a modern office and laboratory with a troffer lighting system.

Photos and data courtesy of Herbert Wile, Jr., Metalcraft Products Co. Inc., Philadelphia, Pa.

BEFORE, a 620- by 100-foot warehouse with its fair share of steel beams, pipes and blowers. ►

Conversion—Warehouse to Office

For the transition of an enormous (620 feet by 100 feet) old warehouse to, of all things, an office, *conversion* is hardly the word. For its relighting system, this goes double. Nevertheless, an old corrugated steel warehouse in Edison Township, N. J., has been changed into a modern office building and laboratory occupied by the Stavid Division of Lockheed Electronics, a division of Lockheed Aircraft Corp.

Probably the most serious problem in relighting was the building's 22-foot ceiling. The vast expanse of the area and the problem of avoiding an "overhead sea" of light was another. The acoustics of the area further complicated the design. Architects were Battisti & Bell Associates, who developed the following solution.

Ceilings were lowered to 11 feet, neatly concealing a myriad of steel beams, pipes and blowers indigenous to the warehouse. Acoustical panels reduced noise level. Lighting goal was 60 footcandles which, though lower than current recommendations, was felt to be the most practical compromise with environmental limitations and economics. This has been achieved with single-lamp troffers using 3100-lumen-output lamps on very close (four-foot) centers. Troffers vary in size to bring the lighting system from wall to wall; complete flexibility is offered for office partitions (not installed when photograph was taken). There are 60 two-foot, 82 four-foot and 3550 eight-foot units. The extruded white polystyrene plastic diffusers were cut to provide space for the top of partitions of any width, thus allowing flexibility in locating partitions and vents. The half-inch depth of the diffuser below the ceiling line directs some light toward the ceiling and upper side walls, reducing the brightness contrast between the lighting unit and the ceiling.

Installation of the system was in three steps. First, the troffers were installed in the predetermined locations, suspended from the natural ceiling. Next, spacer bars were locked into position between the rows of fixtures. The wall angles were installed next, followed by the spacer bars between the troffers and the wall angles. The last step was the laying in of the acoustical panels on the flanges of the troffers, spacer bars and wall angles.

The new user of the space is satisfied with the slim trim lines of the system—and its unusually economical installation.

Lightning Damage Turned to a Profit

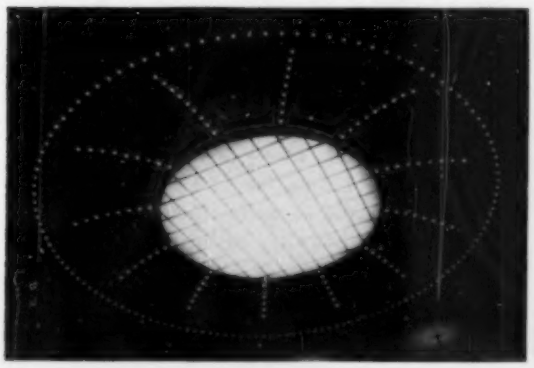
The lightning storm which destroyed the cupola of the auditorium in the First Assembly Church of God, Binghamton, N. Y., eventually had a constructive effect. Need for replacement of the damaged cupola became the occasion for the modernization of an inadequate lighting system which, otherwise, would still be in use.

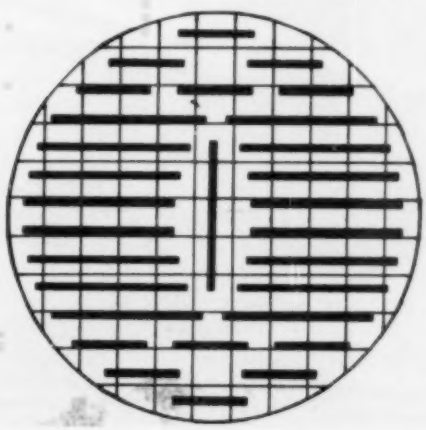
The church auditorium is a 70- by 80-foot area, rising to a height of 38 feet in a ceiling dome. Atop the dome was the cupola, 22 feet in diameter at its bottom rim and, like the rest of the auditorium, decorated with intricate bas relief plaster molding and sculpture. A decorative iron grille at the top of the cupola served as the intake to the exhaust of the auditorium's large ventilating system above.

Since relighting—to higher levels—was to be restricted to the damaged area, a luminous ceiling was the lighting man's answer. The ceiling also proved to be an economy factor since, by concealing the inside of the cupola, it made replacement of the expensive bas relief sculpture unnecessary.

Twenty-nine cool white high-output fluorescent lamps of varying sizes, positioned to provide complete coverage of the cupola (see drawing) were mounted above 2- by 2- by ½-inch cellular patterned, solid, double pan, white, vinyl plastic panels. To permit free flow of air through the ventilating system, without displacement of the shielding panels, the ceiling was dropped 18 inches below the rim of the cupola and became, in effect, a giant suspended fixture. Proper positioning of the floating ceiling in relation to mounting height and room size assured adequate cutoff angle.

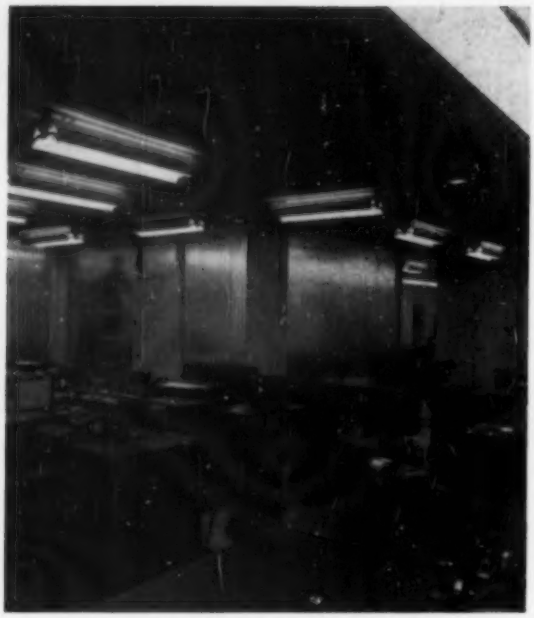
The luminous element is considered by some members of the congregation to have improved the *appearance* of the auditorium. Certainly it has improved the *lighting* by raising the illumination level under the dome to 30 footcandles (it was previously 10), and is one more testament to the feasibility of combining modern lighting techniques with traditional architecture.





Close-up of luminous ceiling (above) and detail of lamp placement for even distribution of light (below).

Second place ALC entry by M. R. Smith, Central New York Section.



160 footcandles in bookkeeping area is marked improvement over 50 footcandles before relighting.

Uniform Appearance for Different Illumination Levels

Orienting a standard unit for the uniform appearance of different areas which require different illumination levels was an important relighting problem in this bank (Home Unity Savings and Loan Association, Philadelphia. The unit used was a four-lamp (40-watt, standard cool white), direct, surface-mounted, two- by four-foot fixture with a plastic diffuser.

In the bookkeeping area (above left), 160 fc is achieved by means of a canny arrangement of the luminaires. Rather than using pedestrian rows of fixtures, the designer has carefully engineered the installation for both over-all appearance and delivery of footcandles where they do the most good. Similar care for fixture layout has resulted in 200 fc over teller cages, as against 115 fc in customer service area (not shown)—all using the same unit in different patterns.

Tellers' cages have 200 footcandles of illumination from carefully engineered arrangement of standard fixtures.

Third place ALC entry by Robert Keough, Philadelphia Section.

Raising the Level— But Retaining Sentimental Lanterns

For as long as the oldest member could recall, the lovely ornamental lanterns in this church have been a part of its beauty and atmosphere. Further, they were a memoriam, donated by still-active members of the congregation, and in relighting, their replacement was unthinkable.

Many a lighting man has faced this relighting problem. Its solution, for St. Stephanus Lutheran Church, St. Paul, was worked out as follows:

With an indirect system ruled out by a poor reflectance of ceiling cross members, and more efficient lanterns not permitted, the relighting design was limited to a direct system. From a 40-foot mounting height, this had to be with sources of high lumen output.

Thirty comfortable footcandles of uniform distribution was the goal. This was achieved by a layout of 12 deep-baffle low-brightness downlights each using a 1000-watt T-24 incandescent lamp. These produce a controlled beam of light which emanates from a 6¼-inch aperture. The specular Alzak reflector is well shielded by the lower portion of the downlight, which contains five baffles finished in matte black, designed to trap spill light and eliminate brightness at normal viewing angles. The fixture is ventilated by a series of holes in the outer housing of the reflector. For maintenance, a six-foot crawl space permits relamping from above.

To compensate for the fall-off under the balcony, the recommendation included ten 300-watt incandescent units of similar design for this area.

Illumination level averages 30 footcandles, with readings of 40 fc directly under the fixtures and 20 fc along the outside walls. With the lanterns no longer a functional lighting element, they have been lamped down to 200 watts to reduce their surface brightness. They have been given a new visual dimension and their decorative effect has been enhanced. No architectural effects have been altered by the new system; rather, they have been brought into view.

Reaction of the congregation: a taste of what lighting can do has spurred further lighting plans —for the stained glass window over the altar.

Second place ALC entry by R. H. Schmall and J. Marshall, Twin City Section.

New Lighting Brings New Income

Conversion of a non-income-producing workshop area in the New York Central Building, New York City, into a rentable space was one of the primary goals of the building's new owners. The area itself, essentially inside space with little window area, deep beams, ducts and obstructions, was hardly promising office space. However, for the McCall Corporation the vacant space offered an opportunity for relocation of the Pattern Department in the home office building — if the space could be made suitable.

Suitability, in this case, meant good lighting. The Pattern Department produces original patterns from sketches of dresses, working with India ink on drafting paper. For the high degree of accuracy required in the work, lighting levels should be at least 150 footcandles, with good diffusion of light for a minimum of reflected glare from the semi-specular drawing materials.

Using a two- by four-foot unit with three 40-watt cool white lamps and dropped acrylic diffuser as the basic lighting component, fixture patterns were developed to fit the structural requirements of various areas. The two- by four-foot module was adaptable to irregular patterns and could be used in continuous rows. Where troffers could not be recessed because of structural obstructions, surface-mounted units with shallow sides were a harmo-

Second place ALC entry by Richard T. Tuck, New York Section.

nious alternative. Tandem units with two-lamp ballasts were used wherever possible for economy.

At the suggestion of the lighting designer, room finishes and colors were selected for minimum reflection factors of: floor, 30 to 35 per cent; walls, 50 to 60 per cent; ceiling, 80 per cent. Three months after installation, measured illumination levels ranged from 210 to 230 footcandles and averaged 215 footcandles, indicating that the system could be maintained at the 150-footcandle design level. Brightnesses, all well within recommended ratios measured: floor, 88 fL; drafting boards, 140 fL; walls, 82 fL; luminaires, 600 fL maximum; ceiling adjacent to luminaires, 61 fL.

The long-term lease for the space signed by the McCall Corporation more than justified the expense for the relighting—the major factor in converting the area into an income-producing space.

Photo and data courtesy of L. F. Krieg, Jr., Pennsylvania Power and Light Co., Allentown, Pa.

Higher Output— In Lighting—In Manufactured Product

Relighting—with high-output lamps and a fixture layout designed to eliminate shadows—increased production and lowered rejections in this shirt factory. The installation is in Plant No. 2 of Penn State Mills, Inc., Allentown, Pa.

Two-lamp 8-foot luminaires use high-output 1500-ma lamps to produce 145 footcandles on the working plane—sewing machines for men's shirts. Luminaires are mounted at a 45-degree angle to the sewing machines, at a 10-foot mounting height, on 8-foot centers. The illumination thus delivered is virtually shadowless.

The rise in production and decrease in rejections have so impressed management that an identical installation is scheduled for the sewing department of Plant No. 1, the company's main plant.

Lighting Does Major Remodeling Job

Given a small lighting budget as part of an overall remodeling plan and a client who objects to spots and floods, suspended, surface-mounted and ceiling-recessed (ceiling was Berger stamped steel) fixtures, one solution is to use the lighting for *complete* modernization of the area. Transformation from the crowded gloom at right to the spacious, attractive women's apparel store below was accomplished with the use of a grid ceiling system with drop-in luminaires.

Three lighting patterns are used to departmentalize the store and counteract its long, narrow (20 by 80 feet) shape. At front, a general illumination system of two continuous rows of four-foot, four-lamp, acrylic plastic, prismatic, low brightness (360 fL average) lens units in the center of the store are combined with incandescent drop-in units along the sides for accent on jewelry and wall display cases. Incandescent units have asymmetric glass lens providing 15-degree vertical cutoff. In the rear of the store, a staggered, checkerboard arrangement of the four-foot units complements the continuous rows at front. Again, incandescent units with concave cross section lens, providing 15-degree vertical cutoff, add low-brightness directional lighting on the dress displays.

Lighting levels of 180 to 200 footcandles are achieved, with good color rendition from the combination of incandescent and deluxe warm white fluorescent lamps. The 150-watt incandescent lamps originally installed have been replaced with 3000-hour, 189-watt street lamps to ease the maintenance problem. Unsightly air conditioning ducts have been concealed behind the ceiling grid in the center of the room with anemostats used for good air distribution.

Second place ALC entry by Andrew Hrivnak, Jr., Cleveland Section.

Third place ALC entry by Francis Clark, Connecticut Section.

In customer area, new lighting system of four-foot, three-lamp troffers uses feeds and openings of former installation.

Improved Q and Q—Little Change in Decorative Effect

Relighting need not always imply a complete change of appearance — an important sales point for customers who want to improve lighting levels, yet are reluctant to sacrifice the decorative character of an area. A case in point is this Connecticut bank where, although lighting levels were increased five-fold, the warmth of the brown and gold decorative scheme was retained.

Originally decorated about 12 years ago, the bank had mahogany furniture, gold carpeting (poorly maintained), walls and ceiling with low reflection factors and a troffer lighting system which produced about 20 footcandles of illumination. In relighting for improved visual conditions, four-foot, three-lamp troffers with 5/8-inch cube plastic louvers were arranged to make use of the openings and feeds of the old lighting system in the customer area. In the higher-ceilinged office area, parallel rows of two-lamp shallow fixtures with pierced straight sides and 45- by 45-degree plastic louvers were mounted to cover the former troffer openings; perpendicular rows of fixtures added to increase the lighting levels. All lamps used are warm white, rapid-start.

To complement the new lighting, dark desk tops were covered with light grey linoleum, ceiling was painted a light yellow and a regular carpet cleaning schedule arranged to maintain satisfactory floor reflectances.

With illumination levels of more than 100 footcandles, good brightness ratios and no sharp shadows or contrasts, the new lighting, rather than destroying the decorative effect, has enriched the appearance of the bank.

Office area, with higher ceiling is lighted by rows of shallow, two-lamp fixtures having 45- by 45-degree plastic louver shielding.

Progress in 1960–
RENAISSANCE IN LIGHTING

Prepared by the Committee on Lighting Progress of the Illuminating Engineering Society

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Norman Falk
R. E. Faucett
John Gornet
R. E. Harz
A. R. Jaeger
Hugh James
W. S. Kolb
E. A. Linsday
F. J. Marriett
E. C. Pauly
T. C. Sargent
S. M. Segal
R. P. Teele
R. R. Tipton
R. F. Townsend

THE YEAR 1959-1960 has seen a renaissance in lighting unparalleled in the past. What location could be better suited to bring out this theme than Pittsburgh—a city which has had its own renaissance both in buildings and appearance, as well as lighting? Pittsburgh's world-famous Golden Triangle illustrates what can be done to a run-down city area. Similar changes have occurred for seeing conditions throughout this continent in the past year. Literally thousands of lighting installations have been made which meet the new levels recommended by IES two years ago. For example, in Pittsburgh a lighting contest conducted last winter turned up well over 100 major lighting installations completed in one three-month period, all over 100 footcandles. This is indicative of reports from all sections of the continent.

Approved by the Council of the Illuminating Engineering Society September, 1960. A Transaction of the IES.

Such widespread application of IES recommended levels is this year's most significant evidence of progress. Two years ago the theme of the Progress Report was primarily progress in *establishing* the then new levels. Last year's "Trek to the West" theme outlined the opportunity for wide *acceptance* of the new levels. This year the "Renaissance in Lighting" is being witnessed literally — a rebirth, a reawakening, a period of vigorous activity in the lighting industry.

New higher output sources have provided means for achieving these higher footcandle levels. A few of this year's many applications which meet or exceed IES levels, along with some of the benefits derived, are reported here.

A hosiery mill reports a 15 per cent increase in production when the level was stepped up from 30 to 150 footcandles. In addition to the production increase there was an accompanying 30 per cent reduction in rejects and 30 per cent decrease in operator training time.

A shoe factory reports 10 per cent increase in production when relighted to 250 footcandles. Better employee morale and a better-made article were by-products of this job. See Fig. 1.

Figure 1. A shoe factory illuminated to a level of 250 footcandles for increased production.

Figure 2. Fluorescent luminaires with extra-high-output lamps provide a 120-footcandle level in this poultry company eviscerating room.

In the eviscerating room of a poultry company, when the lighting was changed from bare incandescent lamps to extra-high-output fluorescent lamps and a 120-footcandle-level provided, a more satisfactory product resulted with better employee morale and better housekeeping. See Fig. 2.

A machine shop with a grid pattern of fluorescent luminaires does not represent progress; this has been done before. But when commercial luminaires with 35-degree by 45-degree shielding are used to provide a level of 200 footcandles, there is an example of a growing trend in lighting. In a printing plant composing room, a luminous plastic louvered ceiling giving 250 to 300 footcandles eliminated the necessity for supplementary lighting. An interesting inspection lighting application provides 1000 footcandles for operators inspecting hydraulic brake cylinder cups. Extra-high-output lamps shielded by adjustable louver fins are used. The seeing task in a high speed warehousing operation is made easy for the crane operator by a lighting installation of mercury lamps providing 25 footcandles. Light-finished walls and dividers and upward light on the ceiling add comfort.

Recessed prismatic glass reflectors using improved-color mercury lamps provide comfortable lighting in a light-finished area used for motor winding. A level of 200 footcandles is provided from units that give 45-degree lamp shielding. See Fig. 3.

The white room of an electrical instrument manufacturer provides an interesting higher level application. A luminous ceiling produces a 300-footcandle-level. This has boosted output 50 per cent, quality levels 100 per cent and cut production costs 20 per cent. The use of jeweler's magnifying

Figure 3. A motor winding area illuminated to a level of 200 footcandles. Luminaires are recessed prismatic glass reflectors, equipped with improved-color mercury lamps.

eye glasses has been greatly reduced. See Fig. 4.

In store lighting a trend to the use of extra-high-output lamps in shielded luminaires provides 150 to 200 footcandles in the installation in Fig. 5. This is accompanied by incandescent display lighting and is topped off with a well-lighted perimeter.

Integration of lighting and structure came more into common usage in supermarkets this past year with lamps mounted between joists. The use of large floating luminous panels over the check-out counter gives a solution to providing increased levels in these areas. A Government post office lobby in Toronto with an aluminum hexagonal celled luminous ceiling represents a departure in lighting for this type of area. See Fig. 6. Lamps are mounted in the ceiling support, directing their light up to the real ceiling to provide 40 footcandles in the lobby area. Supplementary lighting over the counters provides 125 footcandles in that area. The gold and gray anodized screens above the counters are lighted from below with a row of fluorescent lamps.

Floating panels have provided a solution for relighting banking areas to the new levels. These panels simply float in space, retaining the dignity and form of the original structure.

This past year has given many utilities an opportunity to install, in their own properties, lighting that sets an example for today and the future. Thus the concepts of better lighting can be shown locally to interested users.

Typical of good office lighting practice, where 150 footcandles is recommended for bookkeeping, is the use of two-lamp low brightness troffers on three-foot centers. Private offices certainly require the higher levels and this is accomplished easily

Figure 4 (above). A luminous ceiling produces a 300-footcandle level in this white room of an electrical instrument manufacturer. The use of jeweler's magnifying eyeglasses has been greatly reduced.

Figure 5 (right, above). A supermarket lighted to a 150- to 200-footcandle level from extra-high-output lamps in shielded luminaires. Incandescent spotlighting is included for increased levels at displays. Note that additional lighting has been provided at the perimeter.

Figure 6 (right, below). An aluminum hexagonal celled luminous ceiling provides a general level of 40 footcandles in the lobby of this post office. The counters are illuminated to 125 footcandles with supplementary lighting. The gold and gray anodized screens above the counters are illuminated from below to emphasize their decorative appearance.

Figure 7. Slimline T-6 lamps operating at high frequency from a transistorized power supply provide the lighting in this bus.

with troffers designed for the extra-high-output lamps. Luminous ceilings are used to provide the higher levels for drafting rooms, particularly when a high vertical component is required.

Schools have not been left out in the rush for the new levels. Many classrooms are reported with a level of over 100 footcandles. Gymnasiums have benefited also and 100 footcandles is common in secondary schools. Cobo Hall, Detroit's new convention-exhibition building, is lighted with a modular pattern of 2-foot by 8-foot and 2-foot by 2-foot recessed troffers to provide levels varying down from 135 footcandles; 500-watt incandescent spotlights are used when required for highlighting in this 300,000-square-foot area.

Figure 8. Indoor tennis court is illuminated to 75 footcandles in forecourt and 60 footcandles in back courts to provide a comfortable environment for playing club class tennis. Extra-high-output fluorescent lamps are installed in louvered direct luminaires.

The first major installation of transistorized high-frequency fluorescent lighting can be seen in Canada at Hamilton's new City Hall.

New York's Guggenheim Museum illustrates a new technique in art gallery lighting. Here the use of fluorescent lighting to illuminate the pictures is supplemented by light from behind directed at the wall to make the pictures appear to be standing in space.

Even the commuter is sharing in the new levels. Buses using T-6 slimline lamps operating at high frequency from a transistorized power supply became common this year. See Fig. 7.

The use of outdoor jacketed extra-high-output lamps in a cold storage warehouse has brought a new concept of lighting levels to these usually poorly lighted places. New higher levels supplied by extra-high-output fluorescent lamps now make it possible for tennis to be played indoors at any time. See Fig. 8.

Interior Commercial Lighting

Interior fluorescent luminaires continue toward extreme shallowness but side panels and end plates with a third dimension built in seem to be the vogue at the moment. One model features curved metal sides and end plates and a concave plastic bottom lens. Another architecturally-designed unit features flared double walled plastic side panels and formed end plates. This is available with a variety of bottom enclosures. Prismatic plastic enclosures are featured on a number of other new models. See Fig. 9.

One manufacturer has introduced a shallow unit whose diffuser is framed with solid walnut and louvered with a birch grid. The grid hides the lamp streaks of higher brightness. See Fig. 9d.

In recessed fluorescent troffers the trend is to extreme shallowness with simplified mounting accessories. One manufacturer, however, has introduced a deep troffer for use with extra-high-output lamps. This troffer features parabolic aluminum reflectors and cross louvering to provide average brightnesses throughout the shielded zone satisfying the office lighting practice brightness limitations. See Fig. 10. Another manufacturer has introduced a coffered luminaire as a standard item. Heretofore coffers have been treated as custom made items. This is a complete package consisting of coffer and recessed unit.

A recessed incandescent unit with a door that

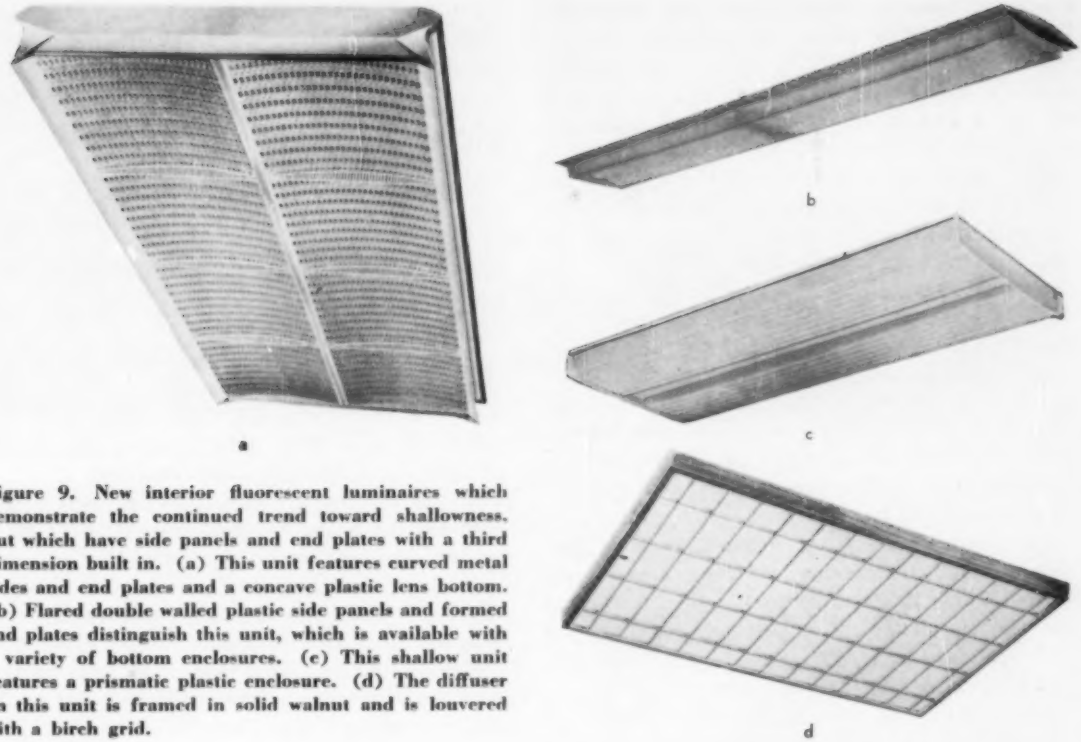


Figure 9. New interior fluorescent luminaires which demonstrate the continued trend toward shallowness, but which have side panels and end plates with a third dimension built in. (a) This unit features curved metal sides and end plates and a concave plastic lens bottom. (b) Flared double walled plastic side panels and formed end plates distinguish this unit, which is available with a variety of bottom enclosures. (c) This shallow unit features a prismatic plastic enclosure. (d) The diffuser on this unit is framed in solid walnut and is louvered with a birch grid.

releases with a touch has been announced by another manufacturer. This unit features a low brightness lens and is particularly adaptable for use in areas which are difficult to relamp. Another manufacturer has introduced a series of close-ceiling mounted units which feature prismatic glassware.

Equipment has been announced which is especially designed for the interior use of the quartz-line lamp. The 500-watt unit, only nine inches in length, is used to provide higher level localized lighting in such places as the interiors of presses or molds. See Fig. 11.

A new porcelain enamelled high-bay mercury reflector lamp protector features low temperature socket operation. This unit also redirects some of the spill light into the working area and provides lamp shielding. A specular aluminum reflector has been designed for use over bare lamps in used car lot lighting to act as both a reflector and lamp protector.

MATERIALS

In the field of luminous ceilings a number of new diffusing media have been announced. One of these is a polystyrene louver consisting of a series of circles. The supporting arrangement is such that a non-modular appearance is achieved although using

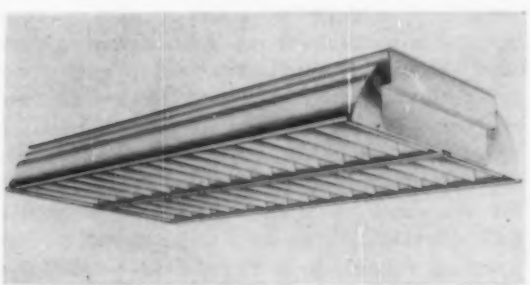


Figure 10. A parabolic aluminum troffer with cross louver which was designed to be used with extra-high-output fluorescent lamps.

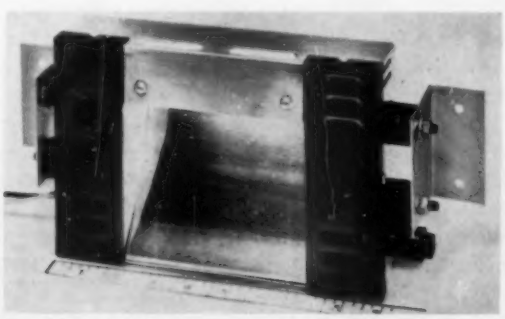


Figure 11. A 500-watt quartz lamp luminaire especially designed for interior use, to provide localized lighting.

a modular material. Another type uses cylindrical holes in a non-combustible vinyl sandwich.

A new polystyrene plastic louver with a special design of each louver fin helps to create a smooth transition between cut-off and maximum transmission zones. A urea plastic louver made available this year has gained listing by Underwriters Laboratories as non-combustible. A clear vinyl plastic enclosure with configurated ribbed surface (as compared to diffusing vinyl plastics) is available for fluorescent luminaires. Curved glass panels to fit fluorescent units with openings up to two by four feet have been manufactured. The familiar square light-diffusing bowl is now made in tempered form to give greater mechanical strength. A technique for applying white porcelain enamel directly to steel is reported to have been perfected this past year. This allows for elimination of the blue ground coat but it is said to require more particular care in the metal cleaning, pickling and pre-preparation. Another reflecting medium reported as new this year consists of sheet aluminum to which is laminated a plastic coated aluminum foil. This can be used as a specular reflector and can be formed with the finish already applied.

Although not an item of lighting equipment, a new wall plate cover for switches and receptacles is available which, it is felt, makes for a better overall appearance. These are made of hardwood to blend in with the wall finishes.

BALLASTS

Two new mercury lamp ballasts have been made available in the past year for operation at extreme ambient temperatures. One of these is a high-temperature-type designed for use in areas that have higher than average ambient temperatures. In fact, it will provide satisfactory operation in ambients up to 150F. The other ballast is designed for low temperature operation and will operate satisfactorily and provide reliable starting down to —20F.

A new weatherproof fluorescent ballast has just been announced by one manufacturer. This ballast has a molded plastic case which is part of the compound, allowing the ballast to be mounted in any position anywhere.

In a solid fill fluorescent ballast introduced this year the case, core and coil are permanently bonded into a single unit. It cannot leak and will operate cooler and quieter than most previous types. The compound in this ballast is a stable thermo-setting material that will not react or combine chemically with any other material in the ballast.

A tester was made commercially available recently for testing of fluorescent luminaires using any of the higher-output lamps. This tester when inserted into the lamp socket indicates whether the circuit is correctly wired.

Light Sources

Continuing indication of progress is the growth curve of the use of light. Department of Commerce figures give sales of lamps in 1945 of 800,000,000; in 1950 of 1,000,000,000 and in 1959 of 1,300,000,000. This represents a 60 per cent increase in this 14-year period.

During this same period, the use of light in trillions of lumen-hours has increased from 1,100 trillion hours in 1945 through 1,800 trillion in 1950 to 3,800 trillion in 1959. This indicates that the use of light is still doubling every ten years.

It would be easy to calculate from these figures that today's lamps are producing twice as many lumen-hours as they did in 1945. The important point is that less than 10 per cent of the existing lighting installations meet today's standards, so at least the same growth is indicated for the future.

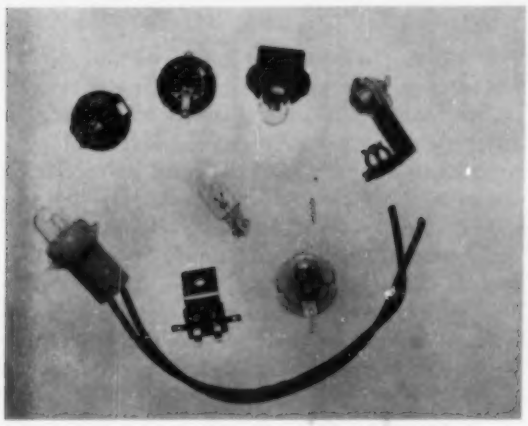
Certain changes in design of quartz infrared heat lamps permit the lamps to be installed so that the seals are outside the hot zone. The ends of the lamp are lengthened and turned 90 degrees from the filament axis with the seals located approximately two inches from the bends, which also permits end-to-end mounting of the lamps to obtain highly uniform energy densities.

Where quartz infrared lamps are used for very high temperature work in testing missiles, a new two-part lead has been developed, the outer portion made of platinum. This greatly increases the life of the seal by reducing oxidation.

A design innovation in quartz infrared lamps enables them to be burned in any position. The new 1600-watt lamp has small dimples in the tube so that the filament-supporting discs are locked in place and the filament sagging problem of vertical-lamp-operation eliminated.

A group of 6.6-ampere iodine-quartz lamps are made in 45- and 200-watt sizes designed particularly for airport runway lighting. Because of their short length, they can be burned in any position and still obtain the nearly perfect maintenance features of the iodine cycle.

A PAR-56 submersible swimming pool lamp operating at 12 volts and 25 amperes meets the need for lighting in pools where it is not practical to build ports into the pool sides. Because of its low operating voltage, the danger of shock is minimized when the unit is operating on isolating transformers. The lamp has a wide-spread beam to give good horizontal coverage across the bottom of the pool.



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b

Figure 12. (a) All glass miniature wedge base lamp and new compact sockets. (b) Electronic T-12 indicator lamp and socket. Note plastic nylon color cap which eliminates need for separately mounted prismatic jewels for color.

The compact R-20 reflector bulb, now available in 30- and 50-watt sizes, fulfills a need for more punch on displays as general lighting levels increase. The same bulb is used for a 200-watt, 34,000K photoflood, making possible a more compact floodlighting attachment for movie cameras.

The new "all glass" miniature "wedge-base" lamp announced last year is being used to illuminate the instrument panels of some 1961 automobiles. Compact sockets, taking advantage of the new lamp design, are in production or prototype stages for both printed circuits and conventional wiring. Some are designed for high speed, automated insertion of the lamp into the socket with attendant cost savings. See Fig. 12a.

Electronic T-2 indicator lamps and sockets are new incandescent developments that provide wide choice of assemblies for design engineers. Plastic nylon color caps simplify identification, and new type strip sockets, easily broken for any number of components, give wide flexibility in easy mounting of single or multiple lamp units on one-half-inch- or three-quarter-inch centers. The color caps eliminate the need for prismatic jewels which require separate mounting. See Fig. 12b.

With the steady advances in farming technology and methods, nighttime operations are achieving ever greater significance. A complete line of sealed beam farm tractor lamps to fill the needs of the many operations performed by these vehicles and their attached implements and accessories has been announced. Available for 6- and 12-volt circuits and in PAR-36 and PAR-46 sizes, they provide five different light distributions.

They are also made for rear mounted use as a combination tail light and implement floodlight. In this form, an aperture is left in the aluminized reflector surface and the exterior of the reflector is red coated. The lamp housing contains a 15-candlepower miniature bulb supported behind the reflector aperture and a double-throw switch. In one switch position the sealed beam unit will flood white light on towed implements. In the other position the flood is turned off and the 15-candlepower bulb lights to shine red light through the aperture and the sealed beam lens. This marks the rear of the tractor for easy visibility when it is traveling on the highway.

Several new incandescent bulb contours, including flame shapes in several wattages, bring new variety to the home and decorative market. Some types are silicone coated and incorporate glass fibers spun around the bulb exterior surface. Weatherproof and shatterproof safety characteristics of these coated bulbs are significant. The charm of their gas flame appearance has appeal in home decor. See Fig. 13.

Mogul based, three-level, R-40 bulbs provide the wide range of 100-, 300- and 400-watt operation,

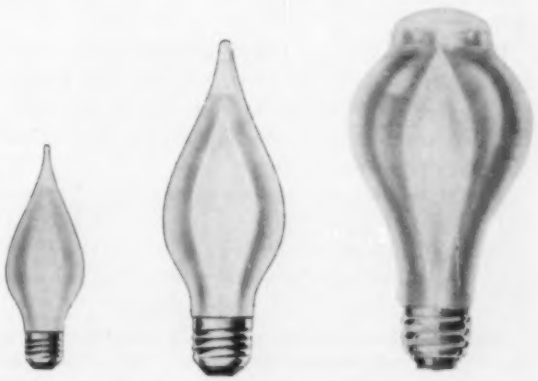


Figure 13. Several new incandescent bulb contours. These are silicon-coated and incorporate glass fibers spun around the bulb exterior surface to give a gas flame appearance for home decor.

the largest sizes yet offered for room lighting. Outdoor decorative and display lamps with colored necks and clear bowls combine 75-watt brightness with weather-resisting silicone coatings. New types of Christmas tree lights include the 15-volt, series burning, miniature base types and the G-14 candelabra base types with translucent color bulbs.

A 250-watt short arc mercury lamp operates on direct current only; the arc of this lamp is said to be very stable and particularly useful as a source in optical systems. Self-ballasted mercury lamps, now up to 1750-watt sizes, are manufactured in clear and phosphor coated types. The double-coiled cathode construction for mercury lamps is available in a complete line of 100- to 1000-watt sizes. This important development offers the advantages of reduced lighting costs, much improved lumen maintenance and increased life to all kinds of mercury applications.

The 1500-milliampere fluorescent lamps continue to dominate the high intensity fluorescent field. Circular cross section lamps are available in standard, reflector, low temperature and aperture types for special applications. Non-circular cross section lamps have been announced in deluxe as well as standard cool white color.

A new family of T-8 (one-inch diameter) fluorescent lamps are available in 24-, 26-, 28- and 30-inch lengths for original equipment installation in appliance and vending machines. They have the important feature of being operable at standard voltage with economical choke-type ballasts. For the first time, fluorescent lamps have been applied in refrigerator cabinet lighting; special adaptations of the rapid-start circuit and lamp principles make this low temperature application practical and introduce new opportunities in appliance styling.

Reflector fluorescent lamps, in various sizes, are specifically designed for photo reproduction equipment. The green-appearing phosphor is designed for maximum actinic effectiveness, which makes high speed processing possible.

A new member of the fluorescent line of colors is a "white" lamp with higher intensity in the red spectrum band, useful in market, commercial or decorative lighting, where the emphasis on red rendition is desirable at fluorescent efficiency.

The first line of flexible plastic electroluminescent lamps was announced this year. The new lamps range from one square inch to 11¾ by 14 inches. They are in the form of flexible sealed panels only 0.30-inch thick. They operate on 120 volts 60 cycles, and are capable of producing from .8 to 4.5 footlamberts, depending on the color—blue, orange, white and green. While electroluminescent lamps still cannot compete with incandescent, fluorescent and mercury light sources for general lighting applications, the new line of lamps will join with other glass and metal base types in finding many specialized uses.

A new PAR-36 100-watt 6-volt lamp is being used for wing tip and tail markers in aircraft. This lamp is employed in a rotating mirror device to create a flashing effect. These red, green and white markers are synchronized to give good depth perception and are arranged so that a flashing signal is seen at a distance and a steady burning marker punctuated by flashes at close range.

Outdoor Lighting

STREET LIGHTING

In the street lighting field there are a number of new developments this year. Mercury luminaires with built-in ballasts have been expanded to include the 1000-watt size as well as the residential sizes. A 250-watt integral ballasted unit is available with top servicing. A kit is available for converting existing incandescent street lighting luminaires to operate small size mercury lamps, thus allowing existing installations, by a simple exchange, to enjoy the higher light output of the mercury lamp. A number of uniquely designed integral ballasted mercury luminaires for pole top mounting have been introduced and are used where conventional equipment would look out of place. See Fig. 14.

Hollywood Boulevard in Los Angeles has been relighted with a specially designed mercury luminaire. This design uses three 700-watt improved-color mercury lamps and is decorated with lighted stars. In the land of movie stars what could be more appropriate than a star-studded luminaire!

There is a trend in many suburban areas, where municipally-owned street lights are not available, to install street lighting on an individual basis. A luminaire with an acrylic open bottom refractor is now available for this purpose. The open bottom allows for servicing from the ground and the acrylic material resists thermal shock and permits .22 rifle slugs to penetrate without shattering. See Fig 14.

In fluorescent street lighting equipment a luminaire with a shielded optical system has been introduced. This luminaire eliminates much of the glare by cutting the light off at 15 degrees below the horizontal and redirecting it to provide a 30

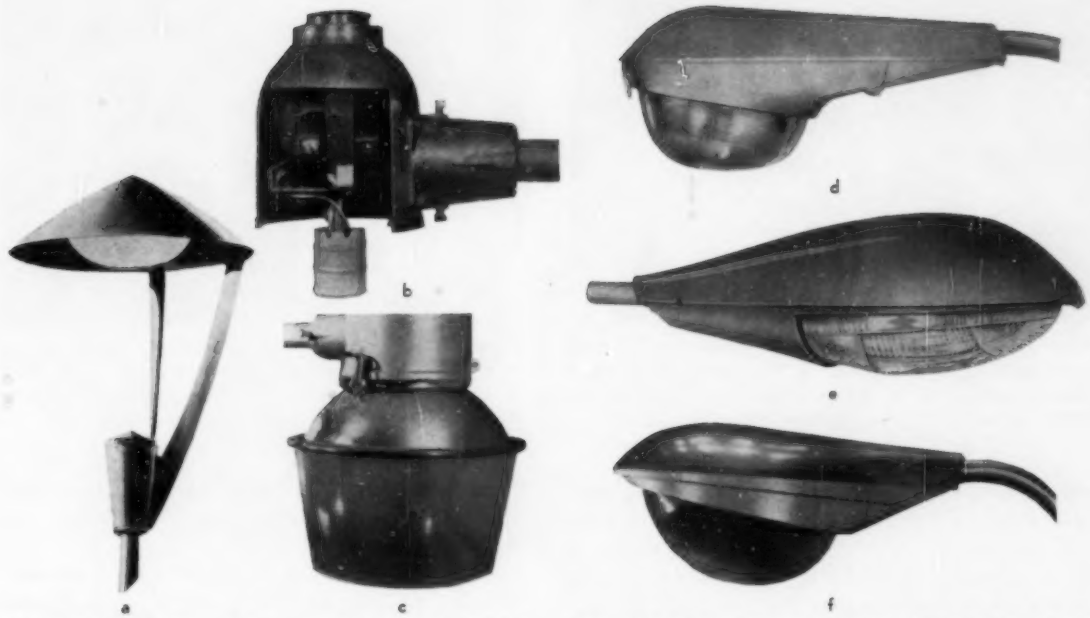


Figure 14. (a) A post top mounted integral ballast mercury luminaire of unique design. (b) A kit for converting incandescent street lighting luminaires to mercury luminaires for the conversion of installations already in existence. (c) An acrylic open bottom refractor luminaire which allows for servicing from the ground. Note that the refractor did not shatter when it was penetrated by a .22 rifle slug. (d) Another new integral ballast mercury luminaire. (e) A 250-watt mercury luminaire with built-in ballast available for top servicing. (f) A 1000-watt mercury luminaire which has the ballast built in.

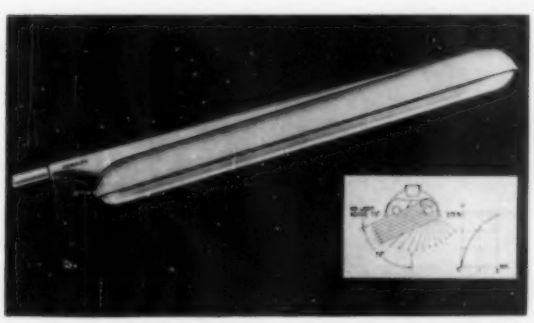
per cent higher footeandle level on the road. Another development is a thermo-electrically controlled fluorescent luminaire which achieves maximum light output over a wide range of temperatures. A heat pump and two thermocouples are employed with the cold junction in contact with the lamp bulb wall. By controlling the bulb wall temperature the mercury pressure within the lamp is maintained at a value for maximum light output. See Fig. 15.

The full scale street lighting outdoor laboratory that was reported a few years ago has now been automated. Pre-selected displays may be set up and activated by a simple pushbutton operation.

A photocell and multiple switch combination for circuit interruption up to 3600 watts has become available in a single package. This combination simplifies wiring, maintenance and photocell mounting.

New wording on pedestrian traffic lights changing from "Don't Leave Curb" in red to "Leave Curb" in green is expected to decrease the confusion caused by the former "Walk" and "Don't Walk" light when the pedestrian is caught in the center of the street as the light changes.

A new two-lamp fluorescent luminaire built into



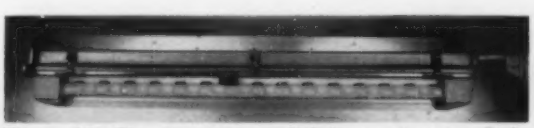


Figure 15. Fluorescent street lighting equipment. Left, a luminaire with a shielded optical system which eliminates much glare by cutting light off 15 degrees below horizontal. Above, a thermoelectrically-controlled luminaire which achieves maximum light output over a wide range of temperatures. By controlling bulb wall temperature in unit, mercury pressure within the lamp is maintained at a value for maximum light output.

Figure 16. Two-lamp fluorescent luminaires are built into the Manahawkin Bridge railing and provide about 25 footcandles on the traveled surface of the roadway. Note the high degree of uniformity.

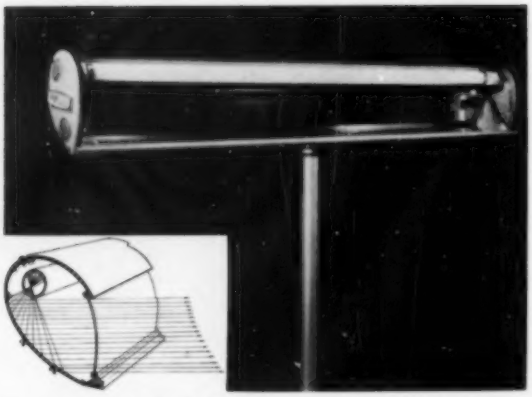


Figure 17. A single-lamp luminaire designed for use with the extra-high-output apertured lamp. The lamp is used in combination with a highly specular reflector in a precise optical system.

the Manahawkin Bridge railing is available in modular form. The railing is 50 inches above the roadway and the unit provides about 2.5 footcandles on the traveled surface of the road with an amazing degree of uniformity. See Fig. 16.

A single lamp luminaire using the extra-high-output apertured lamp in combination with a highly specular reflector in a precise optical system is noted. This unit can be applied where beam spread control is necessary. In this unit the entire brightness of the apertured lamp is collected in a parabolic reflector and directed in a completely controlled beam. Its applications include building facade and sign lighting, ramp, roadway and bridge lighting and airport runway floodlighting. See Fig. 17.

Underpass and tunnel luminaires are now available for use with up to three of the higher-output lamps. By a combination of the various fluorescent lamps a system can be worked out using a single luminaire type to meet all the varying illumination levels required.

The recent lighting of the Panama Canal was accomplished with controlled fluorescent reflector units installed above the water to illuminate the adjacent banks, as shown in Fig. 18.

A transistorized flashing warning light made available during the year flashes for 1/10 of a second 65 times per minute with a 6-beam candlepower flash through red or amber plastic lens. It is used on traffic cones.

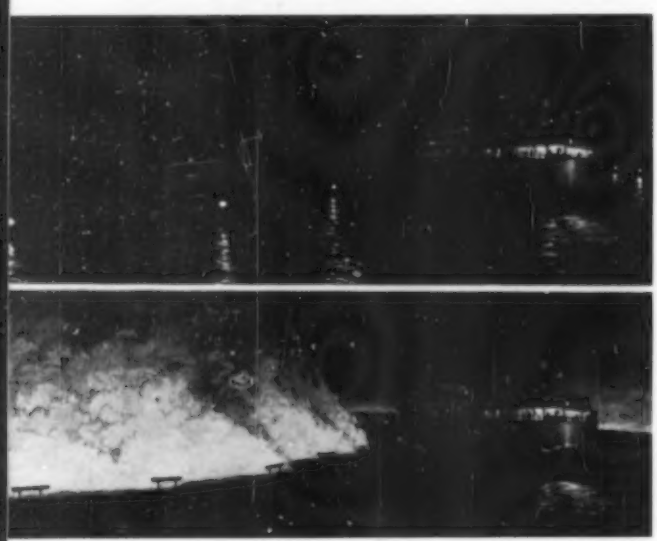


Figure 18. An artist's view of the Panama Canal, showing recent lighting using controlled fluorescent reflector units. These are installed above the water and illuminate the banks of the Canal.

FLOODLIGHTING

The latest technique for landing aircraft is a system called the center-line approach. To accomplish this, light sources are installed in the center of the runway. Several are being considered: one uses a single PAR lamp to produce two beams of light; another more recent type which is very shallow and truly flush uses the 45-watt 6.6-ampere quartz iodine lamp. See Fig. 19.

In addition to this unit using the quartz iodine lamp a number of outdoor and indoor luminaires have been introduced. These units are finding ready acceptance because of their compact size, sharp light control and high lumen maintenance. A dog racing track lighted by this kind of unit illustrates the type of control that these luminaires achieve. See Fig. 20.

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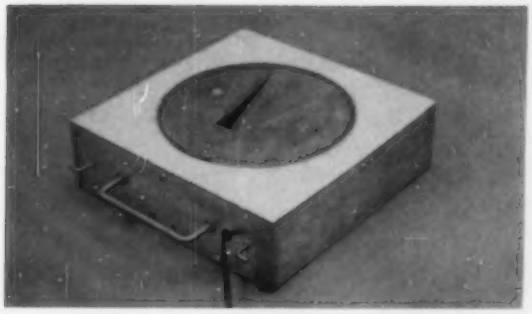

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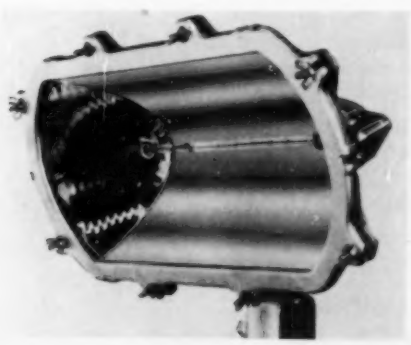
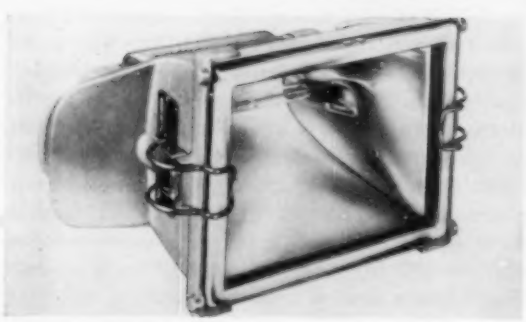
Figure 19. Lighting units used in the latest technique for landing craft—the center line approach system. (a) and (b) Recessed units each using a single PAR lamp to produce two beams of light. (c) and (d) Shallow recessed units each of which uses a quartz iodine lamp.





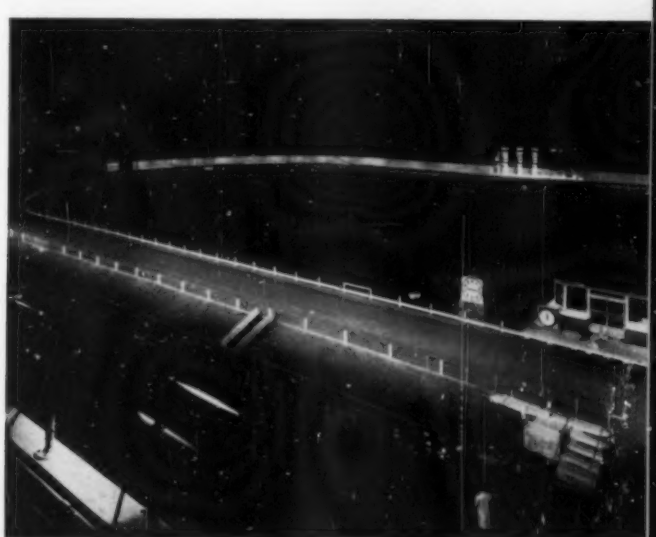


Figure 20. Two examples (left) of quartz iodine lamp luminaires of compact size, good light control and high lumen maintenance. The photograph above shows a dog racing track lighted by this type of unit and illustrates the type of light control that can be achieved.

Figure 21. Wall-mounted outdoor luminaire with prismatic refractor for wide illumination along and away from buildings. This luminaire was designed for use with a 300-watt incandescent lamp or a 175-watt mercury lamp.

A specially designed obstruction light made compatible with disconnect hangers is presently available. This simplifies the difficult maintenance task encountered on rigid mounted obstruction lights.

A new wall-mounted outdoor luminaire with prismatic refractor for use with 300-watt incandescent or 175-watt mercury lamps gives wide illumination along and away from buildings and can be mounted with a 5 to 1 spacing to mounting height ratio. See Fig. 21.

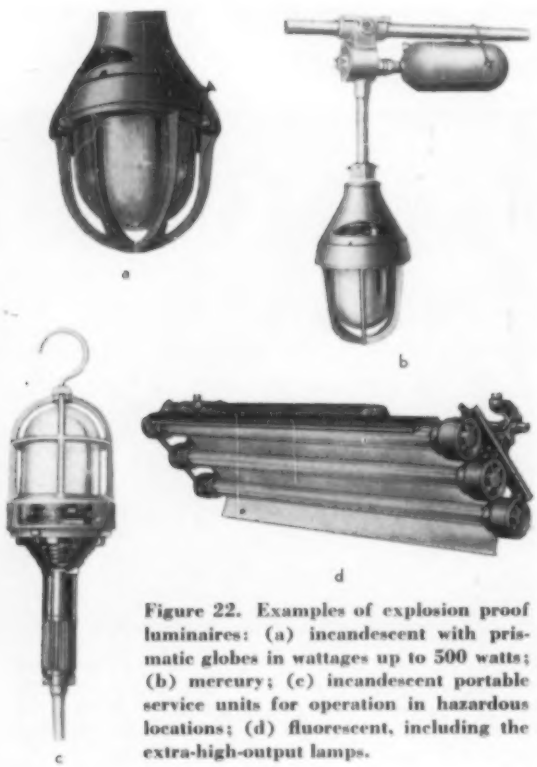


Figure 22. Examples of explosion proof luminaires: (a) incandescent with prismatic globes in wattages up to 500 watts; (b) mercury; (c) incandescent portable service units for operation in hazardous locations; (d) fluorescent, including the extra-high-output lamps.

Figure 23. A spectacular daytime-effective exposed-lamp sign installation on Chicago's Michigan Boulevard. The word "Pepsi" is composed of 279 75-watt PAR-38 spotlamps on one-foot centers.

EXPLOSION-PROOF EQUIPMENT

Explosion-proof lighting equipment with prismatic globes in sizes up to 500-watt incandescent are available this year for the first time. An explosion-proof mercury ballast is now on the market for two 400-watt lamps. The range of explosion-proof fluorescent luminaires has been extended to include the extra-high-output sources. Also available now is an explosion-proof portable service lamp for maintenance operations in hazardous locations. See Fig. 22.

The first explosion-proof surgical room flexible light has been introduced. This is available as a wall or ceiling mounted unit as well as the portable floor mount.

SIGN LIGHTING

The most versatile spectacular, in terms of sign lighting, beams its message down Chicago's Michigan Boulevard as shown in Fig. 23. The word "Pepsi," with the first letter 51 feet high, is composed of 279 PAR-38 spotlamps at 75 watts mounted on one-foot centers. These are burned at full brightness during the day and are dimmed at night to maintain legibility. This technique already is incorporated in many small signs and several other spectaculars. The traveling message sign which is 116 feet long is controlled by electronic means from a nearby newsroom.

Military Developments

The xenon lamp has received much attention from military development personnel this year. A high-pressure short-gap xenon lamp operating from a d-c 50-watt supply is one development. Here, the source length is only one-half millimeter with a peak brightness of 1200 candelas per square millimeter.

Three arcs in a single envelope which may be doubled to six by an auxiliary reflector are possible in a high-pressure, high-brightness multicathode xenon lamp. This lamp and reflector provide a horizontally elongated source for spread beams without central focusing and without the use of a spread lens. Two kilowatts may be divided among the multi arcs or, by a switch, may be applied to the central electrode for higher peak candlepower. This lamp is used for wide horizontal spread searchlights for battlefield applications. See Fig. 24.

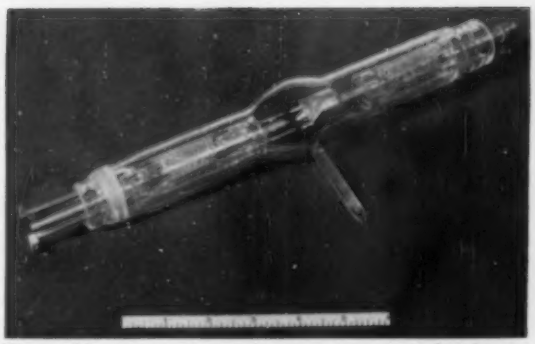


Figure 24. A two-kilowatt, high-pressure, high-brightness multi-cathode xenon lamp. This is used for wide horizontal spread searchlights for battlefield applications.

Testing

Formerly, searchlight testing has involved outdoor ranges of 1000 feet or more, and corrections had to be made for atmospheric attenuation, varying daylight, etc. Now, at Fort Belvoir, Va., a new indoor range in a normal sized room is in operation. In addition to increased convenience, the photometry is done automatically.

A testing laboratory for street lighting luminaires in which mounting heights of 10 meters can be obtained and measurements made at distances up to 30 meters from the point below the luminaire has been built in Belgium.

Interlaboratory measurements on various sizes and types of lamps are carried out on a continuing basis by eight laboratories in the United States to assure uniformity of values throughout the country.

The measurement of photometric brightness (luminance) of red illumination, particularly in the wavelength region 600 to 750 mμ, by physical photometers employing photomultplier tubes generally requires that the brightness values obtained be corrected for true brightness because of mismatches between the response of the sensory elements of the photometer and the CIE luminous efficiency curve. A method has been devised whereby the brightness photometer can be calibrated to measure the chromaticity of the red light and indicate the proper correction to apply for brightness values.

A mechanical stroboscope was developed to inspect the functioning of rotating incandescent light panels mounted on the tips of helicopter rotor blades. These light panels form a ring of light while the helicopter rotor is in motion and therefore individual light panels are not distinguishable. When the speed of the rotating disc in the mechanical stroboscope is adjusted to that of the helicopter rotor blades, individual panels may be observed.

The introduction of extra-high-output fluorescent lamps has placed a greater burden upon laboratories. It is necessary for these sources to remain in the normal horizontal burning position during testing and yet maintain a proper test distance. These difficulties have been overcome in a typical laboratory with only a 12-foot ceiling height. With adequate horizontal space available, two mirrors were used to split the luminaire image, accurately, into two parts. By rotating both luminaires and mirrors a complete candlepower distribution curve can be developed.

Education

Lighting education continues to be given a prominent part in the activities of the Society.

At the request of Council, the Residence Lighting Committee has produced "An Outline for a Home Lighting Training Program." This action is a result of requests for sales training and lectures on home lighting that are received by local Sections and Chapters of IES throughout the country. Society headquarters can now furnish, on request, a copy of the instructors' outline, together with a packet containing reference pamphlets and slide sets with a brief descriptive script.

During the past year the Residence Lighting Forums continued to show an exceptional growth. The number of Forums increased from 11 to 15. The Academy of Lighting Arts graduated over 6000 people in courses held in 180 towns and cities in the Uinted States and Canada. There are reported to have been 56 sponsoring utilities from Boston to Honolulu.

"Control of Light" demonstration kits have been made available to utilities and others as a

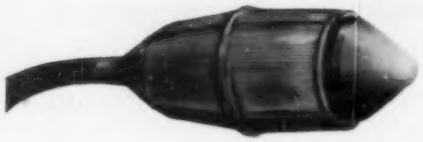


Figure 25. A hermetically sealed reflector and refractor street lighting luminaire with a 140-watt high-output sodium lamp, used in this street lighting installation in England.

tool for lighting education. The "Control of Light" kit together with demonstration technique outline was specifically developed to demonstrate the principles by which light can be carefully controlled and scientifically distributed.

A cost-of-light calculator has been developed for laboratory or field use. Values of lumen output, coefficient of utilization, initial cost, labor cost, energy cost, etc., are set on various scales and by means of mechanical linkages the answer is given in dollars per million lumen-hours or cents per hour per 10,000 square feet.

1959-1960 IES President J. B. Browder was particularly interested in reviving university education in illuminating engineering. Subject to Council approval, he has suggested the establishment of a Task Committee on Education and Professional Standards. This committee, to include many eminent leaders in the lighting industry, will undertake a study of the trend in educational standards for a course of action.

Recognizing the continual and rapid progress in lighting, the Karlsruhe Technical University in West Germany completed, during 1960, one of the most modern schools of illuminating engineering in either hemisphere. Illuminating engineering undergraduate courses will be required for all degrees in electrical engineering. The spacious and elaborate five-story building, operating under the direction of Prof. Paul Schulz, not only contains classrooms and laboratories covering every phase of illuminating engineering, but will also feature graduate and advanced courses in this highly specialized field. In addition to the academic program this building houses ultra modern laboratories for research and development in light sources, photometry and illuminating engineering, a milestone symbolic of progress in lighting.

Foreign

Sodium lighting in England has gained a new impetus with the introduction of a new hermetically-sealed reflector and refractor street lighting luminaire. See Fig. 25. This luminaire uses a 140-watt high-output sodium lamp.

In Italy there are many new outdoor lighting installations. The Island of San Giulio is floodlighted with a combination of incandescent and mercury lamps. See Fig. 26. In Magenta, Italy, trees in the public garden are floodlighted by means of projector spot lamps contained in colored tulip-shaped metal lighting units.

A narrow shop in Melbourne, Australia (Fig. 27) is treated with triangular ceiling panels, of honeycomb prismatic plastic louvers, in order to suggest movement and offset the small width of the shop. Illumination at desk level is 100 footcandles.

Holland has introduced a new luminaire for office lighting that can accommodate three circular fluorescent lamps. 40-, 32- and 22-watt lamps are placed concentrically in a circular recessed unit and the light sources screened by a diamond-shaped plastic louver.

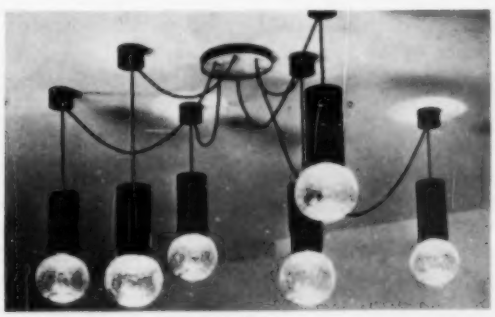
Figure 26. Floodlighting of San Giulio Island on Orta Lake in Italy. Incandescent and mercury lamps are used.

Figure 27 (left). To suggest movement and offset small width of this narrow shop in Melbourne, Australia, the ceiling is treated with triangular ceiling panels. The illumination level is 100 footcandles at the desks.

Figure 28 (below). Entrance hall in the new Lighting Center in Paris. Semi-indirect illumination is from fluorescent lamps mounted in hollow wooden beams of triangular cross sections.

At the new Lighting Center in Paris the lighting in the entrance hall is semi-indirect from fluorescent lamps housed in hollow wooden beams of triangular section. See Fig. 28. These beams are prevented from appearing too dark with respect to their background by the provision of a number of narrow glass covered apertures giving some degree of sparkle. The Lighting Center, which is noncommercial, is dedicated to instructions and demonstrations of the principles of good lighting.

The group of luminaires from England and



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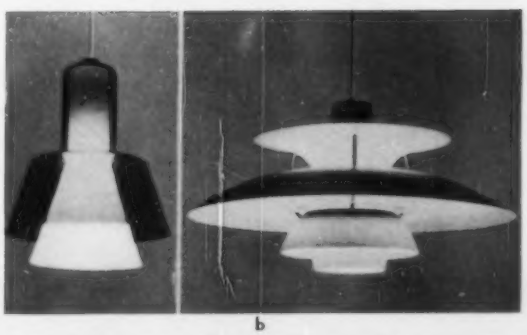

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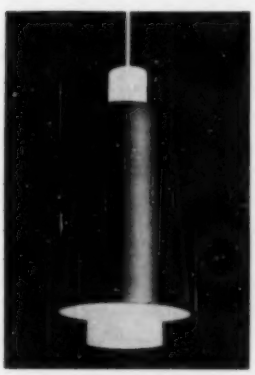

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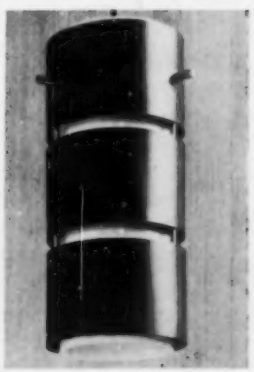

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Figure 29. A group of luminaires from England and Sweden, illustrating the skill of these countries in devising exciting new shapes. Some of the luminaires shown have won international design awards.

Figure 30. Mercury and sodium street lighting luminaires from Germany.

Sweden illustrated in Fig. 29 shows skill in devising exciting new shapes. Flat black metal finishes are combined with white opal glass and plastic. No doubt, some of these may produce high brightness ratios, but one cannot deny their smart good looks. Some have won international design awards.

In Germany a water-filtration plant has been lighted indirectly with 700-watt improved-color mercury lamps. The light is reflected by a shell-concrete roof. Germany has also introduced a number of interesting new street lighting luminaires. See Fig. 30. These include post-top and wall mounted lanterns for the 250-watt mercury lamp. Post-top units are available with an adjustable reflector for varying spacing-to-mounting height ratios. Other types are adaptable for either the 250-watt mercury lamp or for two 60-watt sodium lamps giving a wide distribution. Another model designed for mounting on a concrete column of concave triangular cross section is made of aluminum alloy.

Figure 31. The Parthenon lighted from the inside, with the columns in silhouette, during a performance of a sound and light spectacle.

Throughout Europe, floodlighting of historic buildings is coupled with a musical recording to create a sound and light spectacle. The Parthenon in Athens, for example, is lighted from inside with the columns as silhouettes during a performance. See Fig. 31.

A Woolworth store in England is lighted by an unusual combination of fluorescent and incandescent lamps. The specially designed fluorescent units accommodate three 8-foot lamps at a mounting height of 18 feet. To give better color rendition and to add liveliness to the lighting system, 300-watt incandescent units have been recessed into false ceiling beams. See Fig. 32.

Again in England, an operating room with 68 projector lights and 18 general illumination units recessed in the dome presents an interesting application. See Fig. 33. Normally 12 of the projector lights are used to provide 2000 footcandles at the operating table. All lamps are serviced and switched from outside the room but the switching control is in the room.

Sports lighting developments abroad include an indoor tennis court in France lighted to 20 footcandles by fluorescent lamps in louvered luminaires. In Spain, the stadium of the Barcelona Football Club is lighted with 246 incandescent luminaires, each containing eight parabolic mirrors which project uniform shadowless light onto the playing field. Illumination on the field is 60 footcandles.

The Republic of Brazil is now in the process of completing its new capital Brazilia. As this is an entirely new city, street lighting was planned at the same time as the other municipal services were being designed. Conventional style two- and four-lamp fluorescent luminaires are used. See Fig. 34.

Figure 32. An unusual combination of fluorescent and incandescent lighting in a chain store in England. Note perimeter valance lighting for wall displays.

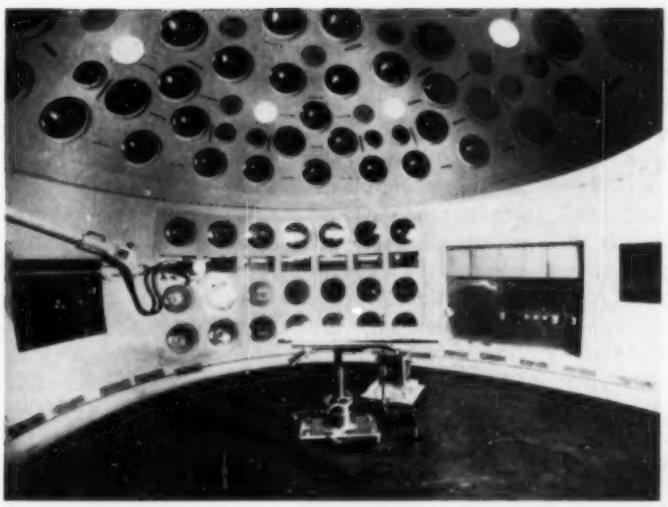


Figure 33. A dome-shaped operating room in England. Light is provided by 68 projector lights and 18 general lighting units recessed in the dome; 2000 footcandles can be obtained at the operating point.

Figure 34. Two- and four-lamp fluorescent luminaires provide street lighting in Brazilia, the new capital of Brazil.

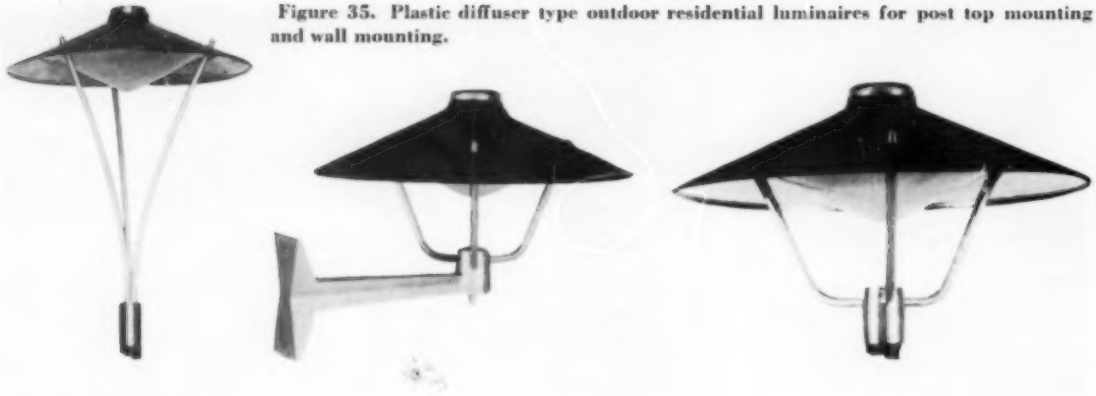


Figure 35. Plastic diffuser type outdoor residential luminaires for post top mounting and wall mounting.

Residential

There is a definite trend toward more outdoor lighting in the residential field. Two manufacturers report a complete new line of equipment. One of these manufacturers uses plastic diffusers (Fig. 35) while the other utilizes prismatic glass (Fig. 36). They are available as post-top units, for wall mounting and for installation under canopies. The prismatic refractor luminaires bring the effective types of light distribution which have, until now, been used successfully in street lighting, directly to home. The units are designed to combine maximum efficiency with modern clean-cut appearance.

An interior residential luminaire designed specifically to combine engineered lighting for the home with a "new look" has been introduced. This unit, which is of the recessed type, employs a prismatic lens for efficient light distribution. It also has a prismatic plastic trim to redirect spill light to the ceiling and shield the source. See Fig. 37.

Another manufacturer has introduced other innovations in residential recessed luminaires. The first luminaire is a multi-grooved baffle unit that has a compressed molded black internal baffle which looks similar to the cuttings on a phonograph record. See Fig. 38. This baffle does an excellent job of eliminating glare. The second unit uses a floating lens with a rich halo of edge lighting over the external trim to give an altogether different appearance in a recessed light.

Traditional type chandeliers are as popular as ever. Some innovations have been made, however. One style has its own internal dimmer which allows for full "on" operation or a low candlelight

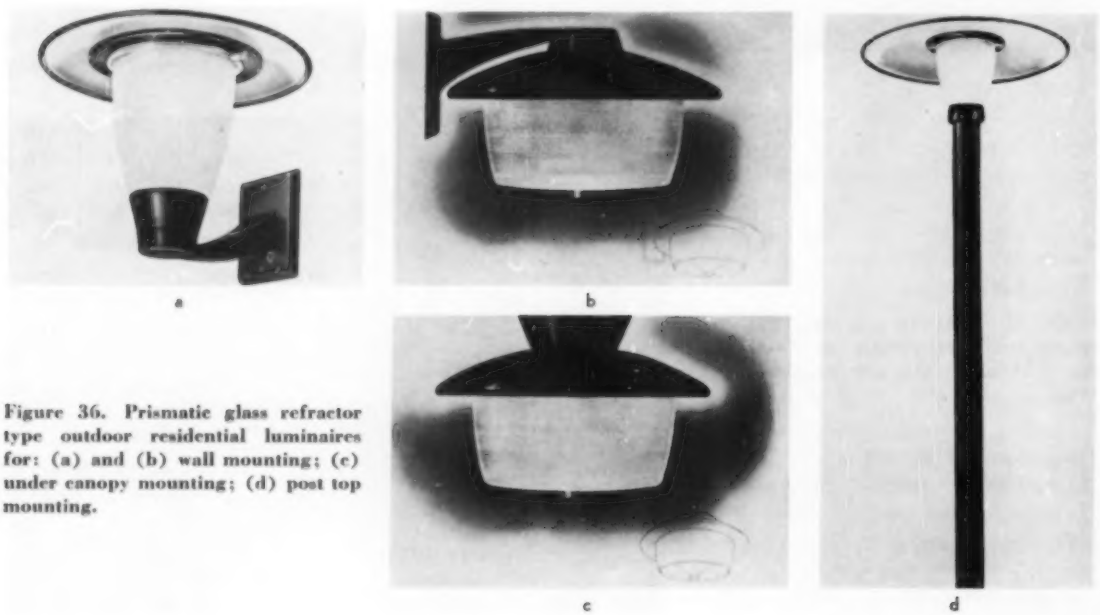
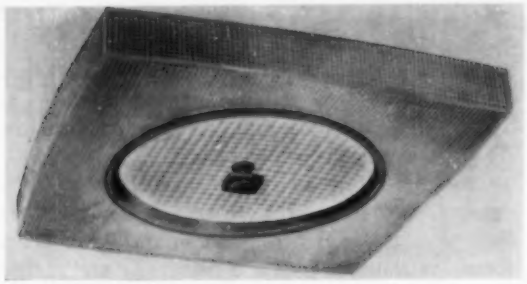


Figure 36. Prismatic glass refractor type outdoor residential luminaires for: (a) and (b) wall mounting; (c) under canopy mounting; (d) post top mounting.



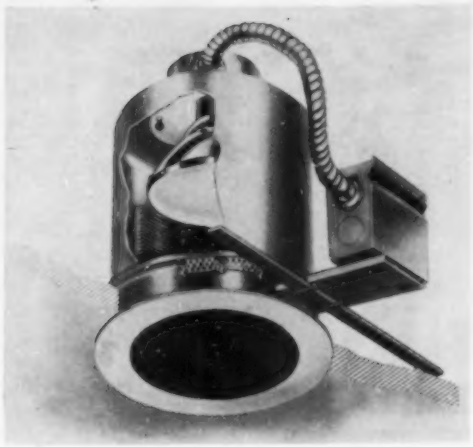


Figure 37 (above). A recessed type interior residential luminaire utilizing a 150-watt incandescent lamp and a prismatic lens for efficient light distribution.
Figure 38 (right). A residential recessed luminaire with a multi-grooved baffle that has a compressed molded black internal baffle similar in appearance to the cuttings on a phonograph record.

level. Others are operated by a remote dimmer. The addition of color to these luminaires effects a bright cheerful appearance. The addition of the new flame-shaped lamp combines the nostalgic beauty of the gas flame with the convenience of modern incandescent lighting. Bold luminaires of contemporary design are becoming more common. The use of bright colors is also another trend.

There is now an adjustable bathroom lighting unit that will give the necessary side light on the face for good illumination for shaving and make-up. It is for use in existing homes where a single luminaire over the mirror is the only outlet available. See Fig. 39.

The trend toward completely luminous ceilings in the kitchen continues. Uniform levels result over the entire room. A luminous wall is reported forming one side of a living room. This adds a bright cheery appearance to the room at all times.

Color in lighting has extended to the garden. Flower-shaped luminaires find many uses in gardens, patios and beside swimming pools, adding much color to any setting. A new line of colored bullet type lights for garden use has been introduced recently. These come in a variety of sizes and colors.

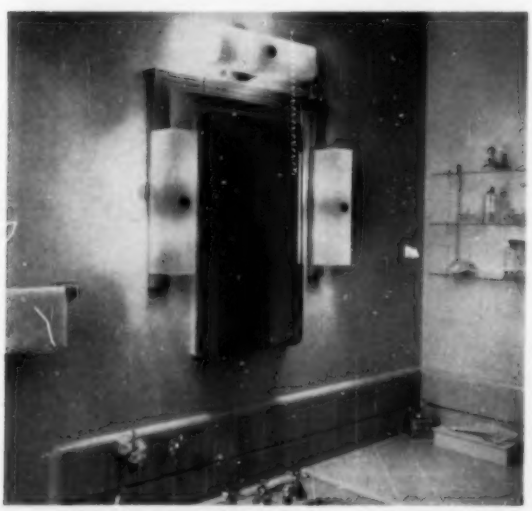


Figure 39. An adjustable bathroom incandescent lighting unit made to replace a single luminaire over the mirror in existing homes. Note that this unit provides important side lighting for the face.

Electrical Space Conditioning

A new industry concept, "electrical space conditioning," was born this year. Previously, the establishment of "light conditioning" was an important concept in controlling the visual environment — illumination, brightnesses and finishes on walls, floors and furniture. Now, electrical space conditioning comes along to encompass the visual and thermal environments.

Briefly stated, electrical space conditioning means that lighting not only provides seeing conditions for greater productivity and profitable operation in offices, factories and stores, but can also provide a major portion of the heating requirements as well. It also means incorporation of lighting with heating and cooling for the greatest value in total building systems. Another major consideration is that this will improve the practicality of the higher levels needed for better seeing. The concept of ESC is just getting started, but already much is going on.

A furniture store in Canton, Ohio, has what appears to be a conventional incandescent lighting system. In winter, air is pumped through the ceiling cavity past the lights and heat pump coils and is introduced to the room in perimeter areas. This same principle has been used in a supermarket

Figure 40. Electric space conditioning in the installation stage. Troffers are engineered to serve as air returns, thereby removing part of the heat from the lighting in such a way that it does not load the air cooling system.

where the lighting supplies 80 per cent of the building heating requirements.

A wide variety of air-handling troffers is now available. Some of them simply serve as diffusers for introduction of cool or warm air. Others are engineered to serve as air returns, thereby removing part of the lighting heat in such a way that it does not load the air cooling system. The Harris Trust Building in Chicago represents a very large installation of this type of equipment. See Fig. 40. New designs and systems are being studied by several manufacturers.

Georgia Power's new 23-story office building in Atlanta is literally heated with light. New IES recommended footcandle levels are used in all areas with the "scissors curve" being strictly adhered to. Rochester Gas and Electric is installing 200-footcandle levels throughout their new building using a similar technique.

In St. Paul, the Emporium department store windows have ventilation taking heat from the windows to help warm the entrances. At North American Aviation, ventilation waste air, which is 25 per cent of the total air circulated, is forced through the ceiling cavity where ballasts are located, thereby keeping the ballast heat from getting into the room.

At Las Vegas Convention Auditorium downlights with 750-watt reflector lamps provide 40 footcandles of general lighting, 80 footcandles over the basketball area, 300 footcandles for boxing, wrestling or special events in the center of the area. Ventilation waste air is exhausted up through incandescent downlights into the ceiling cavity, then to the outside. This removes much lighting heat and solar heat. The main objective of this method was to improve thermal comfort, but it also saved 20 tons in air conditioning.

Comfort heating is another aspect of electric space conditioning that is growing by leaps and bounds. Quartz infrared lamps keep workers comfortable in an open repair shed and at the same time provide 50 footcandles. Here groups of lamps are thermostatically controlled.

Chicago's State Street, famous for its street lighting, now boasts a store front (Carson, Pirie, Scott & Company) with 130 quartz heat lamps above the windows to warm passers-by and attract them to the store with a 500-footcandle level. Summer fashions were modeled on the sidewalk in front of this store in November. See Fig. 41.

Racing fans at Maywood Race Track enjoy the warmth provided by quartz infrared lamps. A total load of 30-watts per square foot gives 70 footcandles of illumination.

In addition, consulting engineering firms are working on many different systems for controlling lighting heat so it can be most effectively used. Next year should see many results from this approach to lighting as a part of the building system instead of just a certain number of lighting units installed in a space.

This report has been prepared as a record of the progress made in the lighting industry during the past year. It is only a small addition to the progress made in the past. Undoubtedly, there has been more progress made even during the time it took to prepare this report for publication and the time taken to assimilate it.

Figure 41. A storefront in Chicago with 130 quartz heat lamps above the show windows to warm passers-by and to attract them with an illumination level of 500 footcandles. The photograph was taken on a November evening.

BCD Appraisals of Luminaire Brightness In a Simulated Office

By WILLARD ALLPHIN

This paper reports the results of a research project in which inexperienced observers adjusted luminaire brightness in a simulated office to BCD, the borderline between comfort and discomfort. One hundred and nine observers performed consistently in appraising six luminaire combinations. Data are given from which glare prediction methods can be checked against the actual conditions studied in the project.

In 1811 Count Rumford discussed discomfort glare before the National Institute of France and gave directions for reducing the glare from an argand lamp. Whether or not people followed his advice, problems of glare are still with us today; and modern light sources and higher footcandle levels make it more important than ever that we attempt to control all types of glare.

Disability glare can be dealt with on a numerical basis, but discomfort glare, being so largely subjective in nature, offers more of a problem. The problem has been studied by many researchers,[1-8] and one of the criteria used has been BCD, the borderline between comfort and discomfort. Since most laboratory work in this field leads to calculations or assumptions about how people in work-a-day siutations will react to discomfort glare, it has seemed desirable to make an investigation under circumstances which are as close to a real-life situation as possible without sacrificing the necessary standardization.

Is BCD a meaningful concept to most inexperienced observers? If so, can they make consistent and repeatable evaluations of actual lighting situations? It was the purpose of this project to ask these questions and, if the answers were "yes," to provide check-points against which systems for predicting discomfort glare can be checked.

Apparatus

Fig. 1 shows the laboratory arranged as a simulated office. Three rows of enclosed luminaires are suspended at an angle such that the diffusing plastic panels of the middle row are normal to the line of sight from the observer to the luminaires.

There are four luminaires in each row and the twelve luminaires are switched in the combinations or "situations" shown in Fig. 2. In situation No.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 11-16, 1960, Pittsburgh, Pa. AUTHOR: Sylvania Lighting Products, Salem, Mass. Accepted by the Papers Committee as a Transaction of IES.

Figure 1. View of simulated office from behind observer.

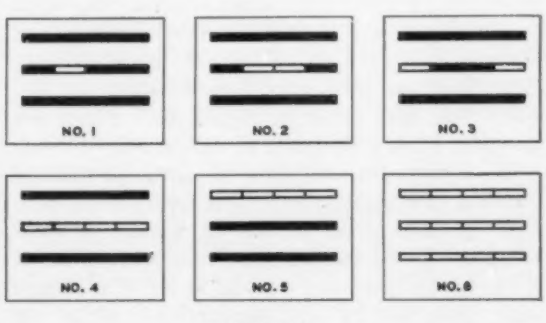


Figure 2. Situations. Open rectangles indicate lighted luminaires.

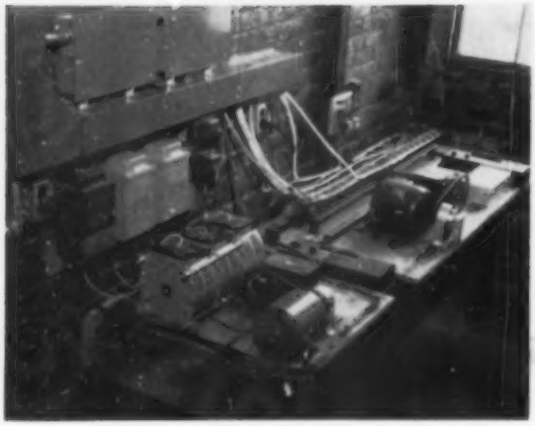


Figure 3. Dimmers for control circuit.

Figure 4. From fixation area toward observer.

5, the lighted row is the one farthest from the observer and nearest his line of sight. Each luminaire contains three high output warm white fluorescent lamps. The observer looks at the fixation area around the X's and adjusts luminaire brightness by pushing buttons which operate the motor-driven dimmer equipment in Fig. 3. The luminaire brightness range is from 40 to 2500 footlamberts. In order to attain this range and this maximum brightness, the dimming cycle is divided into two parts, the upper range being controlled by variable transformers and the lower by rheostats. These can be seen in Fig. 3.

Brightness changes are slower near the upper and lower limits than in the middle range. The change is about 15 per cent per second at the lower end, 25 per cent per second in the middle range and 5 per cent per second at the upper end. The total range is covered in 36 seconds.

On the back of each luminaire, hidden from view of the observer, is a 40-watt T-12 warm white fluorescent lamp which does not change in brightness as the visible panels change. There is also a row of direct fluorescent luminaires behind the observer, which direct light into the room. The walls and ceiling back of the observer are painted dead black so that as little as possible of the variable light from the luminaires is re-directed into the room. The dark bands on the lamps in Fig. 4 are pieces of black paper used to reduce lamp output.

The result of maintaining the surround lighting constant and minimizing reflections from the variable lighting is to provide an almost constant brightness at the fixation area. Even with situation No. 6, the brightness of the wall at the X's changes only from 6.5 to 10.4 footlamberts while the brightness of the luminaires is changing from 40 to 2500 footlamberts. A more complete description of the room and its related brightnesses will be found in the appendix.

The experimenter's position shown in Fig. 5 includes a Spectra Brightness Spot Meter, a tape recorder, and switches for changing luminaire combinations. The brightness meter is mounted on a positioning jig so that it always points at the center of one of the three luminaires necessary to cover the six situations.

Procedure

Members of local organizations served as observers, and the fees were paid into the charity funds of the organizations. In addition, the experiment used engineers (not lighting), supervisors,

Figure 5. Experimenter's controls.

foremen and secretaries from the plant in which the laboratory was located. Observers were not told anything about the project in advance.

Before an observer entered the room, all of the luminaires were lighted to a brightness of about 100 footlamberts. This constituted Situation No. 6. The observer was seated at the desk and allowed to become at least partly adapted to the situation while the experimenter filled out the data sheet. Then instructions were given from a tape recorder through the loudspeaker on the observer's desk so that all observers would receive the same instructions in the same way. The observer was asked to push the upper button and notice that the "fixtures" got brighter. Then he was told to push the lower button and notice that they dimmed. He was asked to raise and lower the brightness several times and then to adjust the brightness to his BCD, the borderline between comfort and discomfort, while looking at the X's.

BCD was described with care, putting the same idea in several ways. For example, it was described as the point where the observer was comfortable, but if the fixtures were any brighter, he would be uncomfortable. He was told that when the brightness was at BCD he should press the chime button on the right, to signal the experimenter, and then relax and look wherever he wished until a new arrangement of fixtures had been made.

When the chime sounded, the experimenter read the brightness meter shown in Fig. 5, then switched off the luminaires. He changed the selector switch to Situation No. 1, the single luminaire, while operating the dimmer controls for increasing brightness. At a brightness of about 2000 footlamberts, the luminaire was switched on, and the observer instructed to make a new BCD setting.

These first two observations were for training purposes and were not used in the computations, but the observer was not told this. After the second observation, further instructions were given from the tape to insure that the criterion was understood. Then the six situations were presented in a sequence which had been previously established for that observer by throwing a die.

Presentations were alternated between high and low initial brightness until two series of observations had been made. Then the high and low starts were interchanged. Thus the observer was started high twice and low twice for each situation. On any second visit presentations were made in the same order as on the first visit.

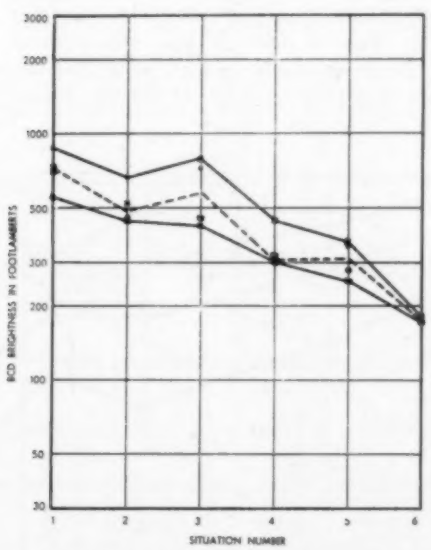


Figure 6. Example of consistent performance, Observer No. 42. Order of presentation: 3-4-6-2-5-1. Closed circle represents the first presentation; "X" represents second presentation; open circle, third presentation; square, fourth presentation.

Results

Most observers behaved as though they knew what they were doing, and few of them asked any questions during or after the instructions. The time for receiving the instructions and making the 26 settings varied between 30 and 50 minutes, with most observers taking about 40 minutes.

Fig. 6 is a graphical presentation of the data from a highly consistent observer. It should be emphasized that the lines are not "curves" in the usual sense. In order to compare with data from other observers, the plotting is in the order of the arbitrary numbers assigned to the situations, but each observer made the appraisals in a different sequence. Fig. 6 simply shows the four BCD values in footlamberts chosen by the observer for each situation. The outer points have been connected by lines in order to help in visualizing the spread of data. The dashed line connects the median values of brightness. Note that the brightness scale is logarithmic, and the median points are midway, logarithmically, between the two inner points.

A few observers gave erratic performances, and it was not possible to tell whether this was because they didn't understand the instructions or because they had no feeling for discomfort glare. Fig. 7 shows data from such an observer. Three times during the session this observer signaled that the situation was at his BCD, without making any adjustment upward or downward. This was in spite of the fact that the situation was sometimes presented to him with the brightness high and sometimes with it low. This "shrugging off" of the task occurred with several of the observers having

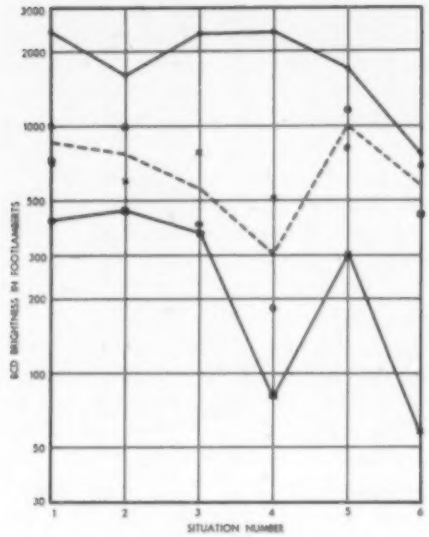


Figure 7. Example of inconsistent performance, Observer No. 2. Order of presentation: 2-1-5-3-6-4.

the widest spread of data. Sometimes, when it seemed evident that the observer was performing erratically, the experimenter went beyond the taped instructions in trying to make the requirements clear. In no such case did the additional instructions lead to an improvement.

A total of 134 inexperienced observers visited the project. Incomplete data were obtained from eight of these for various reasons. In some cases there was an equipment breakdown and other circumstances prevented the observer's return. In other cases the observers moved away from the town.

Of the 126 observers who completed the observations, 17 had wide, erratic patterns like that in Fig. 7. In most such cases also, the experimenter recorded his doubts on the data sheet while the observations were being made. These 17 sets of data were therefore set aside and not included in the analyses. Their inclusion would not have affected the results materially, since they amounted to less than 14 per cent of the total, but it seemed unwise to base any conclusions on such questionable data. However, in one sense the data are not useless. It is a reportable statistic that 14 per cent of the observers were not able to make consistent BCD judgments.

The remaining 109 observers (61 men and 48 women) had patterns like those in Figs. 6, 8, 9 and 10. The pattern in Fig. 9 is about as broad as that in Fig. 8, but it differs in an important particular. In Fig. 9, all data points above the median line were for high brightness presentations and all points below the median line were for low brightness presentations. In Fig. 8, the data points do not relate to high or low brightness presentations. Apparently the adaptation of the observer of Fig. 9 changed considerably more slowly than the luminaire brightness, so that his choices were affected by the brightness levels at which he was started.

Of the 109 observers, five wanted higher brightnesses than the 2500 footlamberts available. The experimenter felt, from conversation and by the way the observers manipulated the controls, that they would have performed consistently had high enough brightnesses been available. Likewise, one observer wanted lower brightnesses than the 40 footlamberts available, and he, also, gave evidence of understanding the criterion. These six observers

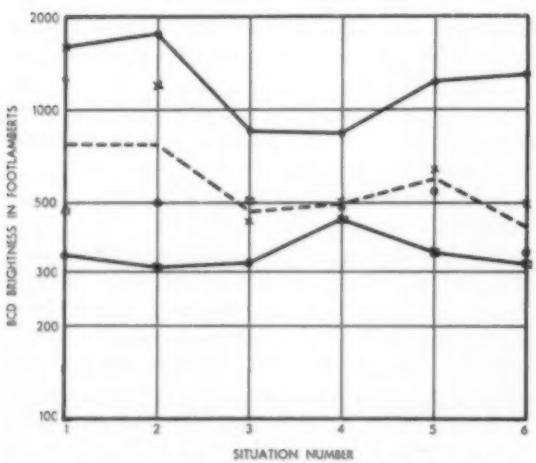


Figure 8. Example of wide pattern, Observer No. 44. Order of presentation: 6-2-4-5-1-3.

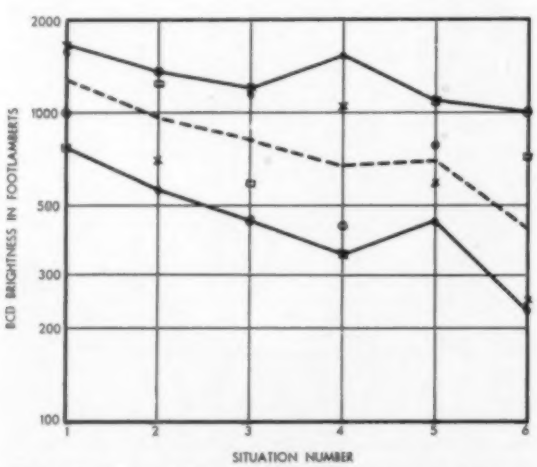


Figure 9. Example of slow adaptation change, Observer No. 34. Order of presentation: 6-3-5-4-2-1.

TABLE I — Portions of Complete Data. Each value is median of 4 BCD settings in footlamberts for one observer. Over-all median fL are at No. 55.

	Situations					
Rank Order	1	2	3	4	5	6
1	<40	<40	<40	<40	<40	<40
2	78	58	49	48	45	41
3	85	83	66	72	47	44
4	87	95	66	76	57	45
5	98	96	90	80	63	45
46	540	470	440	350	335	210
47	550	477	460	360	340	210
48	580	480	460	360	350	210
49	595	480	460	375	350	215
50	600	485	460	390	355	220
51	600	490	470	400	370	222
52	630	500	490	400	390	240
53	630	500	490	400	400	250
54	650	512	500	410	410	250
55	680	540	500	410	410	255
56	700	560	550	420	410	270
57	730	620	570	420	430	275
58	730	630	580	420	440	285
59	740	640	595	430	440	290
60	750	670	600	440	440	300
101	2400	2030	2100	2130	2075	1650
102	2400	2300	2250	2175	2100	1700
103	2450	2350	2350	2200	2200	1700
104	2500	2375	2400	2400	2350	1900
105	>2500	>2500	>2500	>2500	>2500	>2500
106	>2500	>2500	>2500	>2500	>2500	>2500
107	>2500	>2500	>2500	>2500	>2500	>2500
108	>2500	>2500	>2500	>2500	>2500	>2500
109	>2500	>2500	>2500	>2500	>2500	>2500

have been included in the analyses, but it will be seen from Table I that their exclusion would not affect the results substantially.

Table I shows three parts of the complete tabulation of observer median brightnesses. The brightnesses on line 55 are the medians of all observations for all situations. If lines 1 and 105 to 109 were eliminated, the new medians would be at new line 52, or present line 53. The results would not be greatly different, but it is felt that the full number of observers should be included, and this

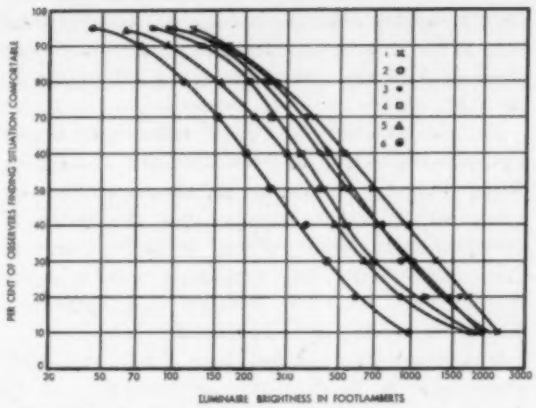


Figure 10. Per cent of observers finding each situation comfortable versus luminaire brightness.

has been done. Fig. 10 puts in graphical form the complete data of which Table I shows a part. These data are for first visits of the 109 observers.

Figs. 11 and 12 are for one observer, Fig. 12 representing a second visit six weeks after the first one. Note that the patterns are quite similar, but the brightnesses are lower on the second visit. For a few observers the brightnesses were the same or higher on second visits. Situations were presented in the same sequence on the second visit as on the first, for each observer.

Of the 109 observers used in the analyses, 23 returned for a second visit and three for third and fourth visits. Whenever the data pattern was compact on the first visit it was equally compact on the second and of about the same shape. The mean variation between first and second visits was 0.22 log unit, downward on the brightness scale. This

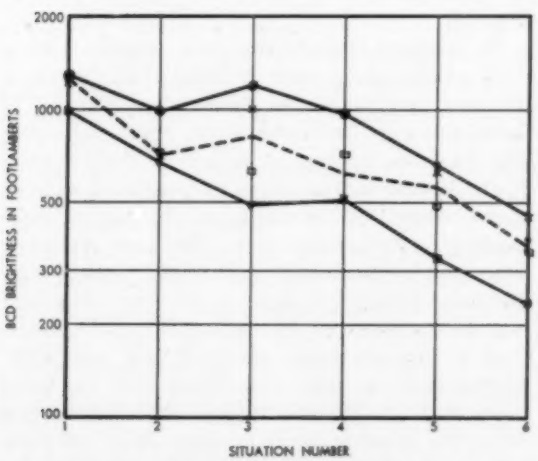


Figure 11. First visit, Observer No. 7. Order of presentation: 4-1-2-5-3-6.

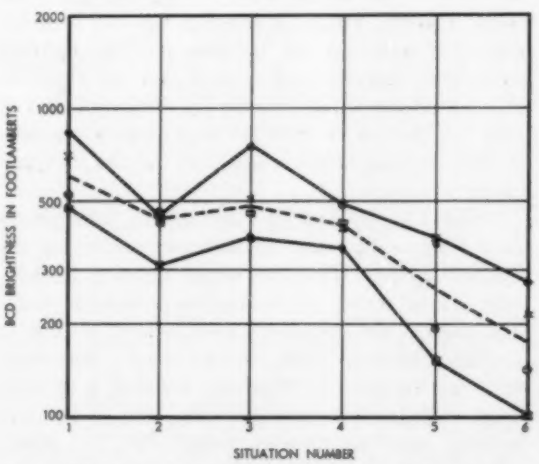


Figure 12. Second visit, Observer No. 7. Order of presentation: 4-1-2-5-3-6.

difference is statistically significant, but involves a much smaller number of observers than the total 109. If 95 per cent confidence limits are set on this observed 0.22, the lower limit turns out to be 0.10 log unit.

For the observers who made four visits, a new sequence was established for the third and fourth visits. This did not change the shapes of the patterns, which would indicate that the order of presentation is not important. Data from second, third and fourth visits were used only to study trends. They were not included with data from first visits for the basic analyses.

Observers' ages ranged from 19 to 69, with approximately half falling between 30 and 40 years. There seems to be no correlation between age and the brightnesses chosen for BCD.

Neither eye color nor the wearing of eyeglasses showed any correlation with brightnesses chosen; however, there was a statistically significant difference between BCD values for men and women, women choosing, on the average, brightnesses almost 0.30 log unit higher than did men. Therefore, medians for an equal number of men and women would be higher than those in Table I. Likewise, the curves in Fig. 10 would be displaced a little to the right if they represented an equal number of men and women.

Differences between brightnesses chosen by men and women diminish somewhat on second visits, but remain enough of a factor so that one could theoretically design a lighting system having higher brightness limits for the same degree of comfort, if all of the occupants were to be women.

The total of 109 observers does not include 12 lighting engineers who visited the project and served as observers. Their data have not been included because the author feels that they find it too difficult to make detached appraisals of discomfort glare. To put it bluntly, lighting installations are designed for laymen, not for lighting engineers. Specific values will not be reported because of the small number of observers, but it may be mentioned that the engineers chose substantially lower brightnesses than did the inexperienced observers.

From Fig. 10 and the descriptive information in the appendix, any method for predicting the discomfort glare from an actual lighting installation can be tested. It is suggested that the shape and slope of the curves are more important in such testing than their exact location along a horizontal axis. As has been pointed out, differences between first visits and repeated visits, and differences between men and women could shift the curves one way or the other. On the other hand, the similarity of those in Fig. 10 is not a coincidence. The situations were different in luminaire position and projected area and the non-uniformities of surround were different. The curves, therefore, support each other in validity because of their similarity.

If there were a "perfect" glare formula and if these curves were completely reliable in shape and relative location, the six curves would become one when translated into Glare Factors. The resultant curve would plot percentage of satisfied observers against Glare Factors. Its absolute position could be adjusted, by engineering judgment, to allow for the variation discussed above, and perhaps for a safety factor. This might very well be done by agreement in a group such as the IES Committee on Recommendations for Quality and Quantity of Illumination.

It may be of interest to see how Harrison-Meaker Glare Factors[5] and Meaker-Oetting VCI's[7] check with these results. The author has been in correspondence with Mr. Meaker and has had his assistance in calculating Glare Factors for several luminaire brightnesses for each situation. From these calculations a set of curves (not shown) was drawn which enables any lumiaire brightness for a particular situation to be translated into Glare Factors or vice versa.

Although Harrison and Meaker have pointed out that Glare Factors have no relative meaning numerically, they should theoretically be the same for different situations having the same median BCD. That is, the 50 per cent curve in Fig. 13 would be a straight line. This curve connects the Glare Factors at which 50 per cent of the observers found each situation comfortable. Likewise the curves at other levels such as 25, 75 and 90 per cent would be straight lines. The author does not attempt to say how straight these curves should be for good agreement, but merely reports them in Fig. 13.

To compare the results with Meaker-Oetting VCI values, their curve relating VCI to Glare Factors[7] was translated from Glare Factors to brightness in footlamberts for each situation. Fig. 14 shows the Ipswich data curve for Situation 5, the Meaker-Oetting curve as translated, and the curve arrived at by applying the Logan-Lange method[3] to the Ipswich data. The latter curve was computed by Emanuel Berger of Mr. Logan's staff. Similar relationships obtain in the other situations but the curves have been omitted to conserve space.

It is not surprising that the VCI' and VCF' curves have the same slope, since both are based upon Guth's BCD data. They do differ significantly from the Ipswich curve in slope. The difference might mean that observers react differently to discomfort glare in a simulated office as compared

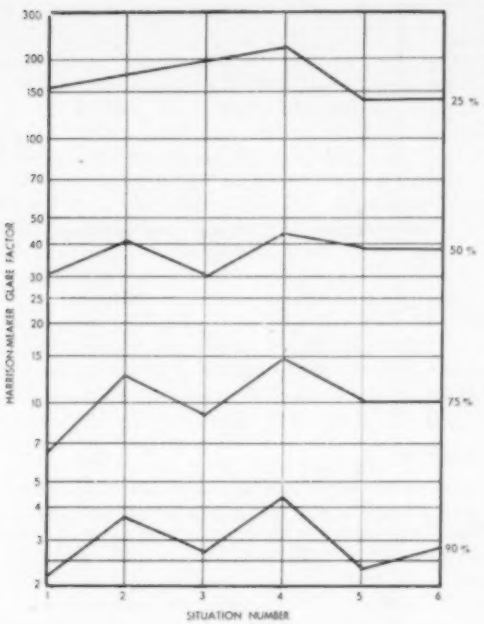
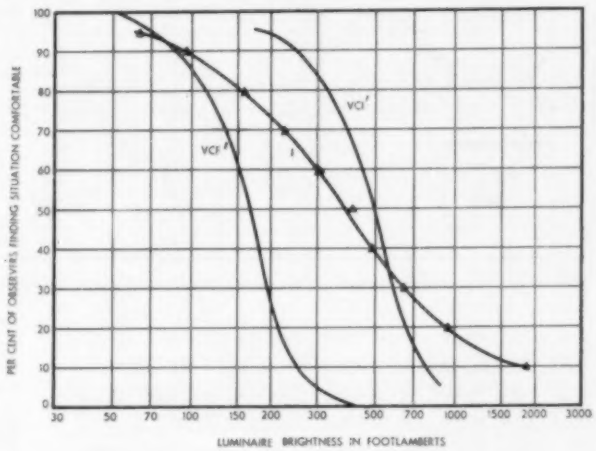


Figure 13 (left). Harrison-Meaker glare factors for data of Fig. 10. Each line is for indicated percentage of comfortable observers.

Figure 14 (below). Situation No. 5. I — Ipswich data. VCI' — Prediction of this situation by VCI method. VCF' — Prediction of this situation by VCF method.



to glare in Luckiesh and Guth's uniform surround.[1,2] Or, perhaps the formula for Glare Factor does not make proper allowance for non-uniform surrounds. In any case, sufficient information is provided in this paper to allow for testing variations of the formula.

Conclusions

Results have been discussed in some detail above. The following are offered as conclusions:

(1) BCD is a meaningful concept to most inexperienced observers.

(2) Most such observers perform consistently when appraising the discomfort glare produced by an actual lighting situation.

(3) Consistent observers repeat their performance patterns on other occasions, but the patterns may be displaced upward or downward on the brightness scale.

(4) Observers differ considerably in the rate at which their adaptation changes with changes in luminaire brightness.

(5) Data are provided by which present and proposed methods of predicting discomfort glare can be checked for six simulated office situations.

Acknowledgements

Members of the IERI Technical Advisory Committee on Light and Vision and Dr. Leonard Mead of Tufts University were most helpful in advising on the design of the experiment, but they are not to be blamed for errors of omission, commission or interpretation. Mr. George A. Meyers of Sylvania, Danvers, designed the original circuit for dimming the fluorescent lamps. Mr. W. P. Lowell, Jr., and Mr. Armand Deschenes and his staff were active in providing the facilities. Mr. F. G. Fales of Sylvania and Dr. Phillip J. Rulon of Harvard University advised on statistical treatment of the data.

Thanks are due to observers from the following Ipswich groups: Catholic Women's Club, Congregational Church Couples Club, Kiwanis Club, Lions Club, Rotary Club, staff, supervisory and secretarial employees of Sylvania plant.

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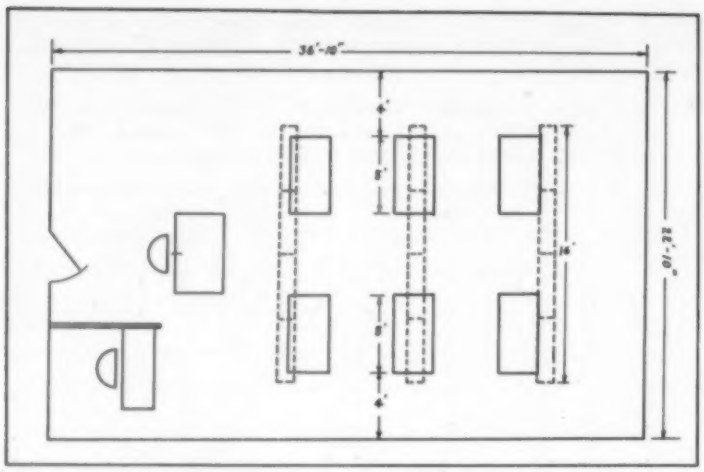

Figure A-1. Plan view of room.

Appendix

Additional information is provided here for those who may wish to check new or revised glare prediction methods against the data shown in Fig. 10. Figs. A-1 and A-2 give the dimensions necessary to establish position factors and projected areas of luminaries. The lighted area of each luminaire is 425 square inches.

Fig. A-3 is a key to the points at which measurements of surround brightnesses were made. The strips of ceiling and upper wall adjacent to the luminaires are as seen from the observer's position.

Fig. A-4 relates the wall brightness at the fixation area "F" to the luminaire brightness for each of the situations studied. Similar charts can be made from the data given in Table II for any of the other points at which the surround brightnesses were measured.

Footcandles at the eye were measured with a single-cell Weston No. 756 meter. The cell was color and cosine corrected and was held vertically, facing the fixation area, "F."

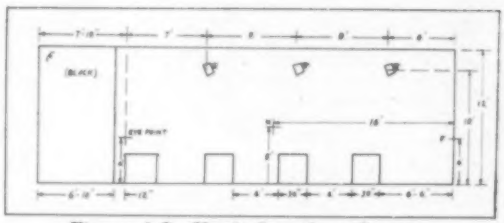

Figure A-2. Vertical section of room.

TABLE II — Reflectances and Footlambert Brightnesses of Points in Surround Indicated in Figs. A-2 and A-3.

Key	Reflectance	Luminaires Off	Situations For Luminaires At 2500 Footlamberts					
			1	2	3	4	5	6
F	29%	6.5	7.0	7.0	7.0	7.3	8.5	10.4
N	29%	3.2	5.2	6.0	8.4	9.6	11.1	17
P	19%	3.5	4.8	6.0	5.7	8.7	6.8	32
Q	26%	3.7	6.1	8.2	8.6	14	14	29
R	26%	3.7	3.2	3.2	3.2	3.8	3.0	7.1
S	23%	3.0	6.5	8.8	7.3	12	7.3	32
T	84%	3.1	32	39	31	46	40	62
U	84%	13	38	45	34	51	23	65
V	84%	34	39	39	40	42	67	76
W	84%	10	19	21	15	22	19	27
X	84%	18	22	20	18	24	27	33
Y	29%	9	10	11	9	10	12	18
Footcandles at eye		5	11	17	17	27	17	85

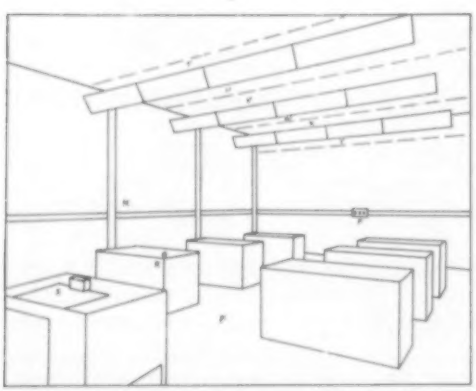

Figure A-3. Location key to points at which surround brightnesses were measured.

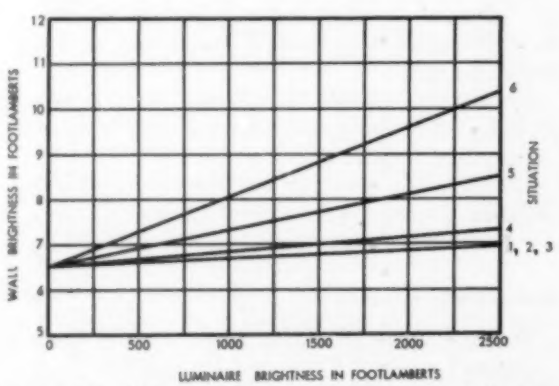

Figure A-4. Relationships of wall brightness at fixation area "F" to luminaire brightness for six situations.

DISCUSSION

S. K. GUTH:* Mr. Allphin has illustrated that a carefully designed and executed investigation will yield significant results. Furthermore, he has demonstrated that most people can make consistent subjective evaluations of discomfort glare in terms of the BCD criterion.

A natural question is: How do the author's results compare with the basic BCD data? For example, would the average Luckiesh-Guth observer rate these six situations the same as the average Allphin observer?

As the result of a recent investigation,[1] we have derived an "exponential" method for dealing with multiple sources which appears to overcome many of the limitations of previously proposed procedures. By this method, a variable exponent is applied to the sum of the individual indices of sensation which are computed by means of the BCD formula.[2] The variable exponent is a function of the number of sources in the visual field.

Using the median values of source brightness for each condition as found by Mr. Allphin, the resulting computed summation of the indices of sensation (ΣM) are shown in Table A. Applying the exponent a shown, the discomfort glare ratings are represented by $(\Sigma M)^a$. According to the original BCD experiments, when a source or group of sources produces a sensation at the borderline between comfort and discomfort, the index of sensation should be equal to 108. As can be seen from Table A, the maximum deviation from this expected value is 10 per cent. The average value for the six situations is 112, which indicates very good agreement.

As a matter of interest, this new exponential method for computing ratings has been used to predict the BCD brightness which would have been obtained if the observers had corresponded to our "standard" observer. These predicted BCD brightnesses and the corresponding Allphin median values are shown in Table B. The excellent agreement indicates that, on the average, Mr. Allphin's observers are similar to those whose data were used for developing the BCD formula. By inspection of Table I of the paper, it is evident that the predicted BCD brightnesses fall within a narrow range of the rank order.

In our papers on this subject we have repeatedly emphasized that averages are useful for determining and checking the relationships among the various factors which are involved. These new data of Mr. Allphin's provide further indications that the BCD formula can be applied to situations other than those studied in our own laboratory.

While averages are important, it also is necessary to consider individual evaluations in order to apply some meaning to glare ratings. Our own practice has been to obtain at least two series of observations from each observer. This is an attempt to ensure that such data are reasonably representative of the evaluations of each individual. In some instances, a third and fourth series are taken. Usually all of the observations are included but on a few occasions it has been found desirable to exclude, by means of standard statistical procedures, those which definitely are out of line.

The difficulty of obtaining repeated series of observations is recognized, especially when large groups are involved. In order to determine the variation of a population, however, it is believed necessary to know the degree to which observations of one individual are truly representative.

The differences between the maximum and minimum values of brightness judged by a specific observer to be at

*General Electric Co., Nela Park, Cleveland, Ohio.

TABLE A — Computed Indices of Sensation Using the "Exponential" Method.

Situation	ΣM	a	$(\Sigma M)^a$
1	104	1.0	104
2	165	.935	118
3	144	.935	104
4	235	.876	120
5	235	.876	120
6	385	.790	110

TABLE B — Comparison of Observed Values of BCD Brightness and Those Predicted by the BCD Formula.

Situation	Observed	Predicted
1	680	705
2	540	490
3	500	520
4	410	365
5	410	365
6	255	250

BCD seem to be somewhat large. As is shown in Figs. 8 and 9, for example, for situation 6 the ratio of maximum to minimum for each of these two observers is almost 5 to 1. This ratio approximates that which we found between our extreme observers in our first BCD investigation.[2] One wonders whether order of presentation, initial brightness of sources, or other factors may have influenced these rather large differences of brightness.

It was unfortunate that the maximum available brightness was a limiting factor for some observers. Furthermore, this limitation may have had some effect upon those who selected BCD brightnesses close to 2500 footlamberts. Of course, the five observers who apparently required brightnesses greater than 2500 footlamberts, as well as the one who wanted less than 40 footlamberts, should have been excluded because they are indeterminates. As was indicated by Mr. Allphin, excluding them will not appreciably affect the median values.

The differences between Mr. Allphin's plot of percentage of observers *vs* BCD brightness and ours is not as serious as is indicated in Fig. 14. The VCI curve he used is based on our 1948 data, modified to a certain extent by an application of the Harrison-Meaker glare rating method. In a later investigation,[1] reported in 1958, we found that 90 per cent of the observers would accept a brightness of about 30 per cent of the average BCD. This compares with the author's data, which indicates that about 25 per cent of average BCD brightness will be acceptable to 90 per cent of the observers. For the range of 50 to 95 per cent of the observers, the relative brightnesses for the BCD sensation are in general agreement.

One point on which Mr. Allphin and I differ is in the method of handling the data. He has used the median, which is calculated very easily. However, with only four observations, the median is completely dependent upon the two middle values. Because all data are included, we prefer the geometric mean, even though it may be influenced to a certain degree by extreme values. Of course, in our own experiments each datum is the result of at least ten observations and hence is not appreciably affected by the extreme values. Furthermore, statisticians generally seem to agree that the median cannot be manipulated algebraically and that the medians of subgroups should not be averaged to obtain the median of the combined group. Fortunately, because of the large number of observers used by Mr. Allphin, the average, whether expressed as the median or

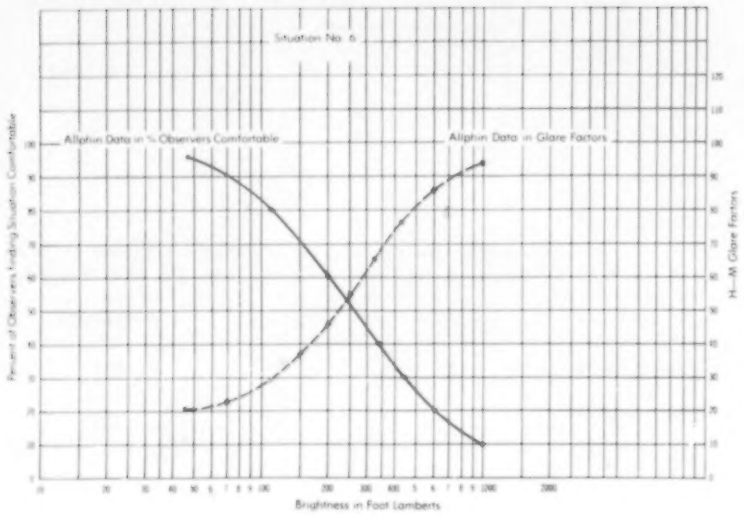
Situation No. 6
Allphin Data in % Observers Comfortable
Allphin Data in Glare Factors
Brightness in Foot Lamberts
H—M Glare Factors

Figure A (Bradley Discussion).

geometric mean, probably would not be greatly different. Nevertheless, it would be interesting to know how much the use of the geometric mean would influence the results, especially those of individual observers.

1. Guth, S. K. and McNelis, J. F.: "Further Data on Discomfort Glare from Multiple Sources." ILLUMINATING ENGINEERING, Vol. LVI, No. 1, p. 46 (January, 1961).
2. Luckiesh, M. and Guth, S. K.: "Brightnesses in Visual Field at Borderline Between Comfort and Discomfort (BCD)," ILLUMINATING ENGINEERING, Vol. XLIV, No. 11, page 650 (November, 1949).

R. D. BRADLEY:* It is my feeling that "room pattern" has a considerable effect on the correlation of the author's data when compared to the work of others. Mr. Allphin has attempted to bring the luminaire brightness into sharp focus, using it as the main variable holding surround brightness and background brightness at a rather constant level. The "room pattern" was varied through six situations, only one of which would be likely to be found in practice. The task is so located that it does not vary in proportion to luminaire brightness. This, unfortunately, is not a very realistic situation, as task brightness is approximately proportional to change in luminaire brightness, with other conditions remaining stable.

*Day-Brite Lighting, Inc., St. Louis, Mo.

I will attempt to correlate the author's data with data calculated using the Harrison-Meaker Glare Rating System; in order to do so, however, it will be necessary to use a correction factor, bringing the task brightness into correct relationship to the luminaire brightness. I have glare factor data on rooms having symmetrical layouts, which will limit the comparison to situation No. 6. Luminaires were selected which have a distribution and brightness pattern similar to the luminaires used by the author. His orientation, however, makes this rather difficult, as the other brightness patterns in the room do not follow the luminaire brightness. The author points out that the "task" (X's) changed in brightness from 6.5 to 10.4 footlamberts while the luminaire brightness ran from 40 to 2500 footlamberts. Obviously, this is not a very realistic situation; however, it does approximate work done by Sylvester K. Guth. The calculated values are based on an adaptation at task brightness which may be considerably different from the brightnesses of the X's on the front wall. Harrison and Meaker also assumed horizontal sight line appraisal for short periods of time.

It should be understood that VCI values are first calculated as glare factors and then then converted to VCI by means of a conversion curve. It is with this known relationship that I am translating observed VCI back into glare factors and plotting them in Fig. A (dotted line shows VCI expressed as glare factors).

TABLE C—Situation No. 6 (Bradley Discussion).

	Production Luminaire Brightnesses in fL from Test Data	Calculated Glare Factors for 50 fc in 20′ x 30′ x 10′ Room (H—M)	Footcandle Level Indicated from Allphin Data Fig. 8	Correction Factor to Adjust Allphin Data to 50 fc (From Published Data)	Adjusted Allphin Glare Factors
Two 40-watt lamps, surface luminaire with glass bottom and sides	350	45	21	.71	48
Two 40-watt lamps, surface luminaire, prismatic bottom and glass sides	314	44	20	.70	45
Two 40-watt lamps, (2′ x 4′) recessed unit with diffusing ribbed plastic	318	49	20		46
Four 40-watt lamps, (2′ x 4′) recessed unit with opal glass	830	107	34	.86	78
Two 75-watt lamps, industrial unit with 10 per cent uplight	930	118	36	.88	82

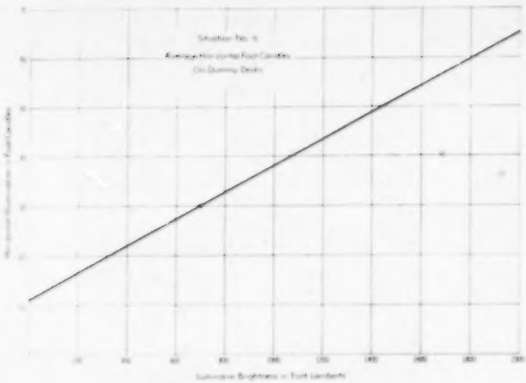

Figure B.

I selected luminaires having brightness patterns similar to the author's and obtained brightness data from previous tests of these luminaires. These values are shown in Table C. The next column of glare factors was taken from published data on these luminaires. In the author's test room, the footcandle level indicated for these brightnesses was taken from Fig. B, made available by the author. A correction factor was obtained from these data and from the "Multiplying Factor for Other Footcandle Levels," published in glare factor tables.[1] Glare factors were read from the author's curve (Fig. A) and the correction factor was applied, giving the adjusted Allphin glare factors at 50 footcandles.

In some cases, the calculated and observed glare factors are reasonably close. However, the slopes of the curves are considerably different, as is shown in Fig. C. The calculated values would seem to be more severe than the observed data in the range of higher brightnesses (above a glare factor of 45). By the same reasoning, they are less restrictive in the lower values. These findings do not surprise me; they merely tend to confirm some eight years of observation using these calculations. A collection of such observations led to the development of new evaluation curves, shown as Fig. D.

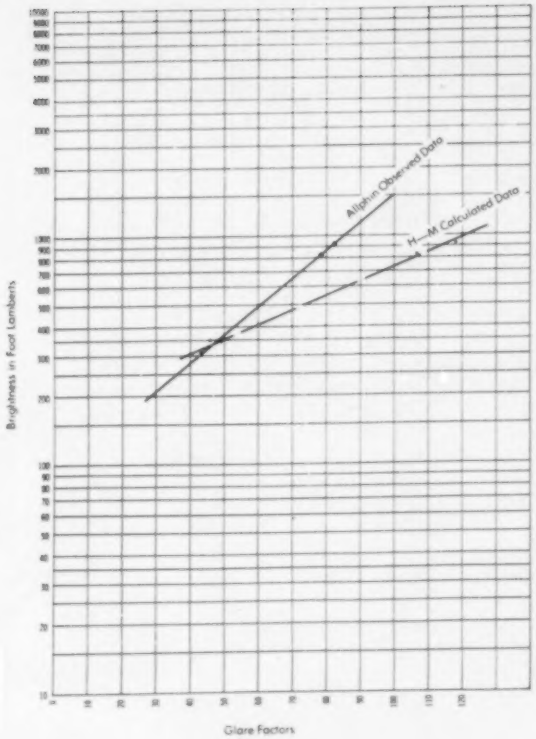

Figure C.

To summarize, the author would seem to have added weight to the Guth experiments and to have confirmed the use of glare factors (or VCI). As we get into higher footcandle levels and higher adaptation levels, the numerical glare factors quite obviously become too restrictive. It is my feeling that there is a middle ground (Fig. D) between the limiting curves, which may prove sufficiently restrictive in areas having light reflective surfaces and intensities in excess of

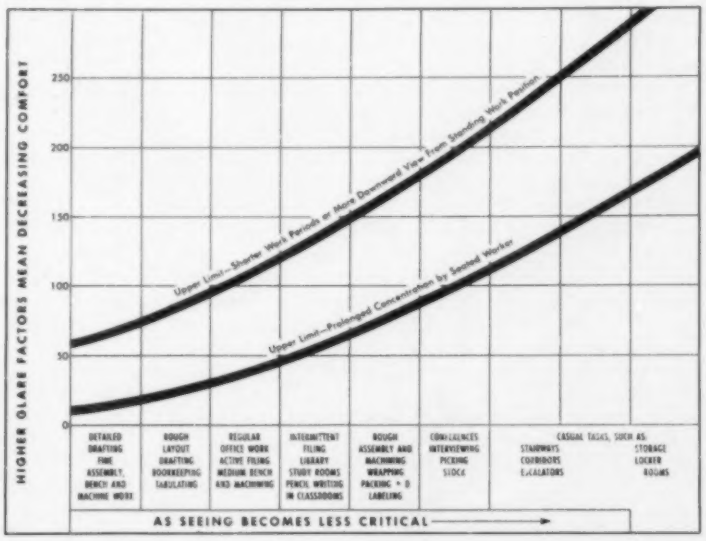
HIGHER GLARE FACTORS MEAN DECREASING COMFORT
250
200
150
100
50
0
Upper Limit—Shorter Work Periods or More Downward View From Standing Work Position
Upper Limit—Prolonged Concentration by Seated Worker
DETAILED DRAFTING FINE ASSEMBLY, BENCH AND MACHINE WORK
ROUGH LAYOUT DRAFTING BOOKKEEPING TABULATING
REGULAR OFFICE WORK ACTIVE FILING MEDIUM BENCH AND MACHINING
INTERMITTENT FILING LIBRARY STUDY ROOMS PENCIL WRITING IN CLASSROOMS
ROUGH ASSEMBLY AND MACHINING WRAPPING PACKING + & LABELING
CONFERENCES INTERVIEWING PICKING STOCK
CASUAL TASKS, SUCH AS: STAIRWAYS CORRIDORS ESCALATORS
STORAGE LOCKER ROOMS
AS SEEING BECOMES LESS CRITICAL

Figure D.

100 footcandles. This same trend is pointed out by Guth and McNelis in their recent paper.[2]

1. Taylor, G. J. and Bradley, R. D.: "Visual Comfort and Cost Analyses for Production Lighting," ILLUMINATING ENGINEERING, Vol. LI, No. 4, page 297 (April, 1956).
2. Guth, S. K. and McNelis, J. F.: "Further Data on Discomfort Glare from Multiple Sources," ILLUMINATING ENGINEERING, Vol. LVI, No. 1, p. 46 (January, 1961).

PHELPS MEAKER:* My interest is mainly in the data on correlation between glare factors and the per cent of people that are comfortable, which we call Visual Comfort Index, or VCI. Mr. Allphin reports that 50 per cent of his observers were comfortable with a glare factor averaging about 37, whereas our VCI ratings, based on Dr. Guth's observers, would call for a glare factor of about 55. As the author points out, there may be a difference in the reaction of his observers as to tolerance of brightness, in comparison with Dr. Guth's group. It is to be hoped that there may be an opportunity to make a detailed comparison of the performance of the two groups according to the same statistical methods.

The correlation between glare factors and BCD was based on the conditions at a point where basic glare factor and BCD characteristics were most similar. At worst, present data may indicate that there should be a shift from this correlation point; we have already recognized that the glare factor-VCI simplifying relationship is not as general as was originally hoped. Many more studies such as this one will offer the promise of real progress.

WARD HARRISON:* I particularly want to compliment Mr. Allphin because he did not choose an entirely unexplored field for his investigation. Rather, he devised a lighting installation which would enable him to check the validity of several methods of measuring discomfort glare which have been advanced by others. If more members of the Society were to follow his example, in their respective fields, I believe that final solution of many of our other problems would be materially expedited.

Mr. Allphin mentions that in his tests the women chose brightnesses about 0.3 log units higher than those chosen by men. Apparently this means that women were satisfied to have the luminaires twice as bright as the men considered comfortable. Am I correct in this? The conclusion seems at variance with the data of other experimenters, who seem to find little difference between men and women in this respect. Perhaps the difference which the author observed would explain why the slope of his curve in Fig. 14 is much more spread out horizontally than the VCI curve on the same chart. Were the women's observations predominately on the lower end of the chart and the men's on the upper end? At 50 per cent BCD, the difference between his value and the VCI curve is much less than at the extremities of the curves.

Mr. Allphin's suggestion about obtaining a large group of observers at a fairly nominal cost is well worth remembering. He explained to me that many people whose services could not ordinarily be hired are willing to cooperate in order to secure funds for donation to a favorite project or charity.

Fig. 13 shows comparisons between glare factor curves and the various percentages of persons satisfied with the installation. A change in the data of one or two observers would make a material change in the brightnesses required for 90 per cent satisfied or for 75 per cent satisfied. Of course, the most significant values are at 50 per cent BCD, since a few observers' determinations one way or the other will not very much affect the final result. I was impressed with how closely the glare factor curve for 50 per cent BCD approaches the horizontal straight line which, as the author indicates, would represent complete agreement. Referring back to Dr. Guth's discussion of this paper, I note that if his suggested values had been applied as corrections to Mr. Allphin's individual readings at 50 per cent BCD, glare factors would have come even closer to a straight line.

In Fig. 13, situation 5, the glare factor is shown to be 37 for 50 per cent BCD, rather than the value of 55 generally used. However, this difference is the direct result of the fact that for 50 per cent BCD Mr. Allphin's observers chose 410 footlamberts rather than 500, as is shown on the VCI curve in Fig. 14.

To my mind a most important result of the author's investigation is that it shows that light source area has a profound effect upon the brightness which can be tolerated. The average BCD for situations 2 and 3 is 520, which is a little more than twice the 255 footlamberts which applies to all luminaires lighted in situation 6. In other words, increasing the source area six times is at least as bad as doubling the brightness.

Another interesting conclusion is that, contrary to the comments often heard, at least those 109 laymen were not at all indifferent to glare. To make the lighting reasonably acceptable, that is, to satisfy four out of five of them, the brightness of the complete installation of luminaires in situation 6 had to be brought down to about 110 fL.

DOMINA E. SPENCER:* Mr. Allphin has shown that coherent BCD data can be obtained from the majority of inexperienced observers. He has also shown that there is a significant difference between the results obtained by lighting engineers and those obtained by inexperienced observers, and has chosen to reject the data obtained by the lighting engineers. I question whether this should be so lightly done.

The inexperienced observer who studied the six luminaire arrangements had no point of reference. He was unaware of the marked difference between the situations presented in the laboratory and the best lighting designs that can be produced. He was, therefore, less critical. On the other hand, the lighting engineer who viewed the situations could recognize, because of his experience, that none of the arrangements presented represented an optimum visual environment. He could recognize that he was being asked to compare a set of situations, all of which were unsatisfactory over the entire range of variables available. How seriously should we regard a criterion which is based on a study of a number of unsatisfactory lighting systems by *inexperienced* observers?

Mr. Allphin dismisses the engineers' data with the comment that "lighting installations are designed for laymen, not for lighting engineers." Perhaps the data of lighting engineers deserve more study. Are we placing ourselves in the position of letting the man in the street formulate criteria for a field of which he is totally ignorant Could it be that the discrepancy between the inexperienced and experienced observers arises merely from the fact that the inexperienced observers do not realize that good lighting is even a possibility? Not having experience with the positive

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*Consulting Engineer, Cleveland, Ohio.
*University of Connecticut, Storrs, Conn.

pleasure of being in an optimum luminous environment, the inexperienced observer does not demand what he believes to be impossible.

Suppose that a group of inexperienced observers were allowed to enjoy, for an extended period, the positive pleasure of working under a well-designed luminous ceiling. If the tests were then repeated, would the inexperienced observers' data be reproduced, or would a significant change in his BCD data result?

I raise a question as to whether in BCD we are measuring the degree to which the public is unsophisticated in the field of lighting rather than a fundamental characteristic of the response of human beings to their luminous environment.

WILLARD ALLPHIN:* Dr. Guth has applied to our data his new exponential method of adding glare sources, with the interesting results recorded in Tables A and B. In my discussion of his paper[1] I did the same thing, with comparable results. I have now computed the indices of sensation again, using the intersections of our curves in Fig. 10 with the 50 per cent line, instead of using the median values from Table I. In some cases these differ slightly due to smoothing of the curves. The new computations are compared with those of Dr. Guth in Table D; also included are values computed for the levels at which 75 per cent of the observers were comfortable. Again the results would plot as a fairly straight line, which is an interesting confirmation of his exponential method.

In regard to multiple visits, if we had had each observer return for one or more repeat visits it would have reduced the total number of observers we could have used. When it became apparent that observers had similar patterns on subsequent visits, it seemed better to curtail the number of repeats in order to deal with a greater total number of observers. It is true that the patterns shifted upward or downward somewhat on repeat visits, but in the ultimate application of such data, an engineering judgment (probably by committee action) should be made on how much to shift the composite curve along the brightness scale. Allowance could be made for differences between experienced and inexperienced observers, for differences in response between men and women, and for safety factors. The relationships between situations are more important than the absolute values, in that they offer a means of checking methods for adding sources of direct glare.

Dr. Guth comments on the rather broad patterns of data in Figs. 8 and 9, and asks whether the spread could have been caused by order of presentation or initial brightness of sources. Careful study of data from all of the observers reveals no apparent influence by presentation order. A few observers were influenced by whether the presentation was at high or low brightness. Fig. 9 is offered as an example of one such observer. However, the median line remains significant because, for each situation, two presentations were made at high brightness and two at low brightness.

Observer No. 44, whose data are plotted in Fig. 8, was an exception to the observers who repeated their patterns. He performed on four occasions and each time his pattern became more compact than the time before.

It is agreed that the maximum brightness available may have had some effect upon those who selected BCD brightnesses close to 2500 footlamberts. However, the elimination of this influence would have increased the difference in slopes at the lower ends between the Ipswich and the VCI curve in Fig. 14. On the other hand, one would hope that lighting installations would not be designed for such low VCI's.

Our statistical advisors remain convinced that the use of the median is valid for dealing with data of this kind. Dr. Guth states, "However, with only four observations, the median is completely dependent upon the two middle values." It might be pointed out that with 40 or 400 observations, the median would still be completely dependent upon the two middle values. In regard to the two middle values, their median and their geometric mean are the same, since their median was located on a logarithmic scale. I have recomputed some of the sets of four observations and find the geometric mean of the four is quite close to the median.

Mr. Bradley's statement that only one situation would be likely to be found in practice is open to argument. However, even the atypical situations confirm both the Harrison-Meaker and the Guth exponential methods of adding glare sources. I cannot agree that from the standpoint of lay observers it is unrealistic to have the luminaire brightness change much more than the surround brightness. I don't think the observers had any expectations of what should happen as they pressed the buttons. Obviously we could offer much better check points for glare rating systems if we could hold the surround brightnesses fairly constant.

Unfortunately, I must point out that the correlation between our work and Mr. Bradley's calculation methods is not nearly as good as he feels it to be. In his Fig. A, the curve labelled "Allphin Data in Glare Factors" is wrong by a wide margin. It should appear as the curve connecting the circles in Fig. E. This curve is not open to much argument since it is based upon straightforward calculations for different luminaire brightnesses in Situation 6. The calculations were made by Mr. Meaker and myself, using the Harrison-Meaker formula. Mr. Bradley arrived at his curve in a roundabout way, after assuming that certain commercial luminaires were like the ones we used. That this assumption was incorrect is shown by the difference in slope of the curves. Therefore, the numbers in the column labelled "Adjusted Allphin Glare Factors" in his Table C are in error, particularly the last two. By the same token the line, "Allphin Observed Data" in Fig. C is incorrectly labelled. These represent Mr. Bradley's calculations based upon the luminaires he has chosen and upon the assumption that the luminaires are similar to the ones used at Ipswich.

Mr. Meaker is concerned with the difference between our observers and Dr. Guth's at the 50 per cent level. Considering the very different conditions, I do not feel that this difference is very great. What I do feel is important is the difference in slope of the curves in Fig. 14. As Dr. Guth has explained in his discussion, however, later work has shown a curve with less slope at the upper end.

Dr. Harrison is interested in the difference between brightness values chosen by men and women, and asks if the women's observations were predominately at the lower

*Author.

TABLE D—Computed Indices of Sensation (ΣM^a) Using the Exponential Method.

Situation	Guth Values for 50 Per Cent VCI	Allphin Values for 50 Per Cent VCI	Allphin Values for 75 Per Cent VCI
1	104	109	55
2	118	123	69
3	104	104	55
4	120	122	68
5	120	128	59
6	110	109	63

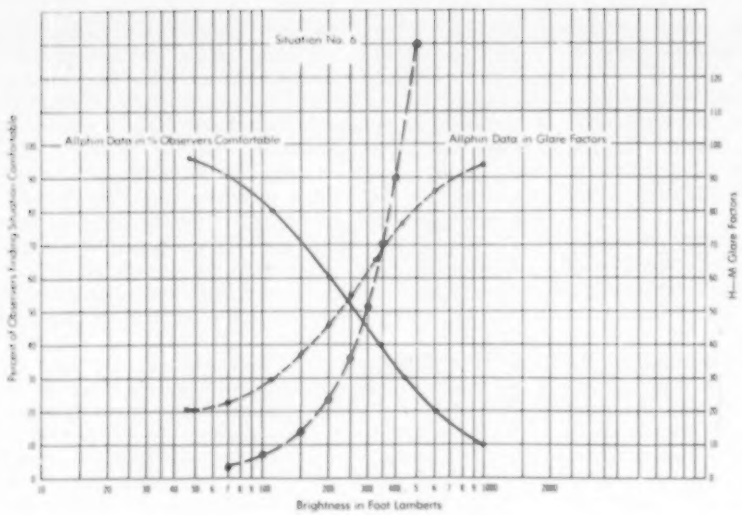
Situation No. 6
Allphin Data in % Observers Comfortable
Allphin Data in Glare Factors
Percent of Observers Finding Situation Comfortable
H—M Glare Factors
Brightness in Foot Lamberts

Figure E.

end of the chart and the men's at the upper end; the answer is no. When plotted separately, the curves for men and women are parallel. Evidently men are the more sensitive creatures.

The plaudit for the method of obtaining observers must be passed along to Dr. Mead of Tufts University, since the suggestion was his.

Dr. Spencer has, I believe, actually added support to my reasons for not including data from lighting engineers. The question was not one of "best lighting designs" or "optimum visual environments" or "positive pleasure of being in an optimum luminous environment." By careful instructions from the tape recorder, the observer was led to concentrate on the question of whether a particular luminaire or group of luminaires caused discomfort while he was looking at the fixation area. Thus, a series of check points could be found with which glare prediction formulas could be tested. In particular, the points would test the most difficult part of such a formula—the addition of glare sources. I believe that any emotional approach to the observations, such as would be made by a lighting engineer interested in a particular technique, would have muddied the results.

1. Guth, S. K. and McNelis, J. F.: "Further Data on Discomfort Glare from Multiple Sources," ILLUMINATING ENGINEERING, Vol. LVI, No. 1, p. 46 (January, 1961).

High Levels Go Underground

Recommended illumination level for salt mines is not included in the listing in the *IES Lighting Handbook*. Nevertheless, safety, miners' comfort and efficient production are critical factors in the industrial task. At the Morton Salt Co.'s mine in Fairport Harbor, Ohio, the traditional string of bare incandescent lamps has been replaced by two-lamp luminaires housing 1500-ma high-output fluorescent lamps. Photo at left shows 20 footcandles supplied for the salt crushing operation. Good lighting here promotes safety and helps to improve the production and maintenance operations. Photo and data courtesy General Electric Co., Cleveland, Ohio.

A.I.A. File No. 31f

INSTALLATION AT DAVIS PHARMACY, 4523-25
BALTIMORE AVE., PHILADELPHIA, PA.

Lighting a Building Facade Sign

LIGHTING OBJECTIVE: To illuminate a store's sign for advertising and identification purposes and to provide general facade and sidewalk illumination.

GENERAL INFORMATION: This corner store's facade is 52 feet in length (24 feet on the side with "Davis Drug" and 28 feet on the side with "Davis Pharmacy") and is 12 feet in height. The sign letters are dark red, have a reflectance of 4 per cent, are 24 inches high, and have a four-inch stroke. The sign background is white (80 per cent reflectance). The building walls and steps are light grey stone with an 11 per cent reflectance.

INSTALLATION: Lighting on the 28-foot side is provided by four Revere Electric Mfg. Co. Fluoresign Outdoor Luminaires with clear plastic covers, three eight-foot units and one four-foot unit, in a continuous row. The 24-foot side is lighted by three eight-foot units in a continuous row. Each eight-foot unit is equipped with one 96-inch, T-12, 1500-ma cool white fluorescent lamp. The four-foot unit is equipped with a 48-inch, T-12, 1500-ma cool white lamp. These eight units are installed three feet out on pipe arms, 12 feet above the sidewalk.

After 300 hours of operation, the illumination varied from 150 footcandles on the sign to 60 footcandles on the sidewalk. Brightnesses were: sign background, 120 fL; sign letters, 6 fL; and building stone wall, 12 fL.

Lighting designed by Thomas P. Ferris, Application Lighting Engineer, Philadelphia Electric Co., Philadelphia, Pa.

Lighting data submitted by Thomas P. Ferris and George T. Anderson, Jr., Philadelphia Electric Co., Philadelphia, Pa., as an illustration of good lighting practice and to aid in the design of similar installations.

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1-61

A.I.A. File No. 31f

Further Data on

Discomfort Glare from Multiple Sources

By SYLVESTER K. GUTH
JOHN F. McNELIS

PRIMARY objective of investigations of discomfort glare is to provide information which leads to the development of a method for predicting, with reasonable accuracy, whether a lighting system will be acceptable. During the past 15 years a number of independent investigators in this country and abroad have provided considerable experimental data. Others have contributed by analyzing the data and suggesting ways in which it might be applied to practical situations. In spite of this great amount of effort, a number of questions remain unanswered and a completely satisfactory method of dealing with discomfort glare continues to be an elusive challenge. Important among these questions are those which concern large luminous areas and multiple sources.

As was pointed out in a previous paper,[1] the generalized conclusions derived from detailed laboratory studies must be substantiated by, or modified in accordance with, the results of investigations with typical lighting systems. The latter may range from only a few to a large number of discrete luminaires and to extensive luminous areas which fill most of the upper portion of the visual field. Theoretically, the ceiling of an infinitely large room would encompass about 44 per cent of the visual field,[2] and would subtend a solid angle of a little over two steradians. However, even in very large rooms, structural elements and acoustical baffles usually reduce the size of the luminous area to a considerably smaller value. This helps to simplify the problem of studying large sources, especially in terms of the physical arrangements necessary to obtain them.

One of our continuing objectives is to determine how the basic discomfort glare data can be applied to practical lighting systems. The limited data of several previous investigations[3, 4] resulted in the development of tentative proposals for accomplishing this. However, certain limitations restricted the general applicability of these methods to many practical situations. More recently, a procedure suggested by Fry[5] was used and appeared to have considerable promise.[1] It was obvious that more experimental data were needed to provide additional checks on these methods and to help determine the necessary modifications so that they could be applied to any type of lighting system.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 11-16, 1960, Pittsburgh, Pa. AUTHORS: General Electric Company, Radiant Energy Effects Laboratory, Nela Park, Cleveland, Ohio. Accepted by the Papers Committee as a Transaction of IES.

Basic BCD Comparison

It always is desirable to be able to determine how well subjective evaluations made by one group of observers agree with those made by other groups. Therefore, before studying luminous areas corresponding to those encountered in practice, it was decided to first "calibrate" the observers in an experimental situation identical to that used in the basic investigations.[6] This included a portion of an 80-inch photometric sphere in which the observer's head was positioned so as to locate his eyes at the center. Thus, the environment consisted of an unrestricted visual field of uniform brightness. A 1.48-inch diameter test source, located on the horizontal line of sight, subtended a solid angle of 0.0011 steradian.

Twelve observers, all but one of whom had taken part in a previous investigation,[1] participated in this study. They were selected on the basis of their collective performance as compared with the results obtained by the entire group of 50 observers and for their individual consistency. Thus, with one exception, they were experienced in making discomfort glare evaluations and comparisons.

In this part of the investigation the observers were required to adjust the brightness of the test source until the sensation produced by it was at the borderline between comfort and discomfort or the BCD sensation. This is termed the BCD brightness of the test source. The momentary exposure method, described in detail elsewhere,[6] was used. Evaluations were made with field brightnesses ranging from 10 to 200 footlamberts. The mean values of BCD brightnesses obtained by the group of observers are presented in Table I and are indicated by the solid circles in Fig. 1. The relationship between field brightness F and BCD brightness B_t

TABLE I—Observed BCD Brightnesses B_t obtained in the Sphere and in the Simulated Room for Various Field Brightnesses F.

	Field Brightness F				
	10	20	50	100	200
Sphere	970	1340	1980	2680	3580
Simulated Room	930	1450	1975	2775	....
Average	950	1395	1978	2728	3580

plot is a straight line on logarithmic coordinates, as shown by *A* in Fig. 1, and can be represented by the equation

$$B_t = 357\ F^{0.44} \qquad (1)$$

The linear relationship agrees with that found in previous investigations.

Also shown in Fig. 1 (broken line) is the relationship obtained in the basic BCD experiments[6] for the same size of test source. This is represented by

$$B_t = 302\ F^{0.44} \qquad (2)$$

The agreement in the exponent of F is particularly significant and shows that the effect of increasing field brightness was judged the same by both groups of observers.

The larger value of the coefficient of F as determined in this experiment indicates that the present group of observers, on the average, is about 18 per cent less sensitive to brightness than the group which took part in the original BCD investigation.[6] That is, for a given size and position of the test source and a specific field brightness, they will accept a higher brightness for the BCD sensation. This difference is consistent with that found in a previous investigation,[1] and, of course, was to be expected because the 12 observers were selected as representative of the 50 observers who participated in that study. When making comparisons with the basic relationships, it is necessary to take such differences into consideration.

Simulated Visual Environment

The primary purpose of this investigation was to obtain visual discomfort evaluations with various combinations of luminous elements which correspond to those found in typical lighting systems. It was not intended to determine the BCD brightnesses of these combinations, but rather to obtain data which might provide some clues as to how they combine to produce a given visual sensation and how to deal with them mathematically.

Experimental Conditions

In order to investigate the factors involved it was necessary to devise an experimental arrangement which would permit complete control of various environmental brightnesses. This is difficult to achieve

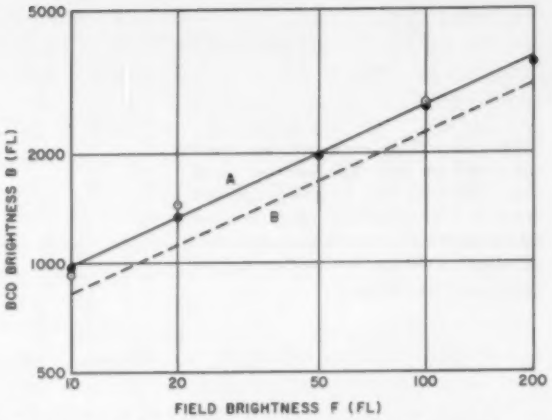

Figure 1. Relationship between BCD brightness B_t of test source located on line of sight and field brightness F. Solid circles are for data obtained with uniform field brightness in 80-inch sphere; open circles for data obtained in a simulated visual environment. Broken line represents results of the basic BCD investigation.

in an actual room. Therefore, it was decided to use a visual environment in which actual conditions could be simulated. The arrangement is illustrated in Fig. 2 and corresponds to a room 34 feet long by 20 feet wide with a luminous ceiling mounted 9 feet above the floor. The physical details of this room were projected upon a vertical plane normal to the horizontal line of sight 3 feet from the eyes. The luminous ceiling was assumed to consist of 63 elements, each 2 feet by 4 feet in size, arranged in nine lengthwise rows as shown in Fig. 3. The observers were located at the point marked "X." For simplicity of control, the entire ceiling area was of uniform brightness. Also shown in Fig. 3 is the average limit of the visual field for the group of observers. Only that portion which could be seen

Figure 2. View of experimental condition representing a luminous ceiling (Condition *A*). The comparison source is located on the line of sight.

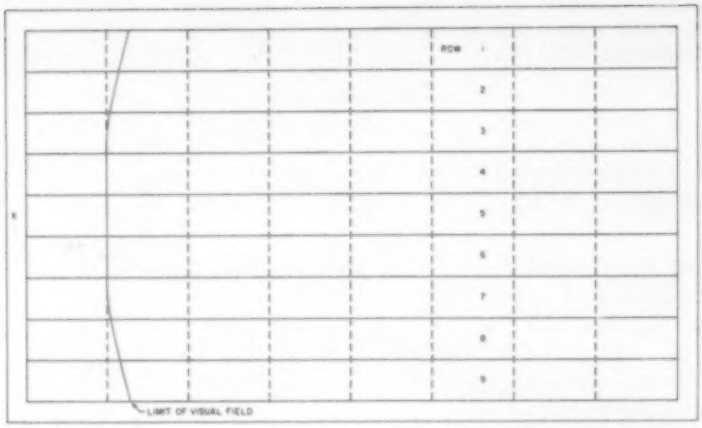

Figure 3. Plan view of the room simulated by the experimental condition. Observer was located at position marked "X". Curved line near observer position represents average limit of visual field on the ceiling for the group of observers.

was included in the computations and comparisons.

The ceiling area was so constructed that white panels could be inserted to cover any portion of the luminous region. Thus, evaluations could be made of the entire ceiling or any desired portion of it. In the present investigation, this variable was confined to various combinations of lengthwise rows. Further studies are planned and will include crosswise rows and individual ceiling elements.

The reflectances of the floor, walls and non-luminous portions of the ceiling were 30, 50 and 80 per cent, respectively. The brightnesses of these areas were controlled independently from that of the luminous portion of the ceiling by lamps located above and to either side of, and well shielded from, the observers. For purposes of comparison and computation, the brightness of the wall was considered to be the field brightness *F*. The brightness of the ceiling could be varied to a maximum of about 1800 footlamberts, which was more than adequate for present purposes. The maximum available wall brightness was 100 footlamberts.

Experimental Procedure

Using the momentary exposure technique, two types of evaluations were made: BCD and comparisons. Both involved the use of the Discomfort Glare Evaluator[1] which was developed for use in this type of experimental situation. As in the case of the sphere test, the observers adjusted the brightness of the test source, which was located on the line of sight, until it produced the BCD sensation. During these evaluations the movable shield of the Discomfort Glare Evaluator was in the down position. This prevented the luminous ceiling area from being seen by the observers. The brightness of the shield was approximately the same as the wall brightness. BCD evaluations were obtained during every experimental session and so provided a continuous check on the observers.

The comparison method was used to obtain evaluations of various combinations of the rows of luminous ceiling elements. That is, the source on the line of sight—now termed the comparison source—and the ceiling area were alternately exposed to view, and the observer adjusted the brightness of the former until it produced the same visual sensation as the particular group of ceiling rows being evaluated. At all times, observers' eyes were fixated upon the position of the comparison source. Since the original BCD investigations involved the same type of comparison source and experimental procedure, it should be possible to make calculations and comparisons regardless of the physical characteristics of the luminous area being evaluated.

Experimental Results

BCD Evaluations

It is desirable to know how BCD evaluations made with the non-uniformities of the simulated room compare with the uniform field brightness of the sphere. The mean values of BCD brightnesses obtained by the group of observers for wall brightnesses ranging from 10 to 100 footlamberts are presented in Table I and indicated by the open circles in Fig. 1. It is evident that the differences between BCD evaluations obtained with the two experimental conditions are not significantly different. This indicates that if areas of high brightness are excluded from the field of view, the BCD brightnesses are primarily a function of the wall brightness. It is recognized that in a very long room, brightnesses of other surfaces close to the line of sight may have some influence upon the BCD evaluations. Nevertheless, in this specific situation, the wall can be considered as representing the field. The lower brightness of the floor area has no apparent effect. This agrees with the results of a recent experiment in an actual room.[1]

TABLE II — BCD Brightness and Comparison-Source Brightnesses for Various Ceiling Brightnesses and a Wall Brightness of 20 Footlamberts.

BCD of Test Source	Ceiling Brightness			
	100	200	400	600
1455	895	1295	1935	2500

BCD brightness of ceiling = 245 fL.

In all subsequent parts of the present investigation, the wall brightness was maintained constant at 20 footlamberts. In terms of a typical light distribution and a wall reflectance of 50 per cent, this corresponds to a lighting level of about 80 fc.

BCD of Full Luminous Ceiling

As the first step in studying various elements or portions of the luminous ceiling, it was necessary to obtain evaluations of various brightnesses of the entire ceiling. From such data, it then is possible to determine the BCD brightness of the ceiling. Using the comparison method, the observers adjusted the brightness of the source on the line of sight until it produced the same sensation as a specific brightness of the simulated luminous ceiling. It was done in this manner because it was more convenient to have the observers adjust the brightness of the comparison source than that of the ceiling. Previous experience with this technique has indicated that both procedures produce the same results. The means of the comparison evaluations by the 12 observers of four ceiling brightnesses are summarized in Table II. By interpolation, the brightness of the ceiling which produces a sensation at the borderline between comfort and discomfort is 245 footlamberts when the wall brightness is 20 footlamberts.

It often is asked whether the brightness of a continuously exposed ceiling would be equal to that of a momentarily exposed one for the same visual sensation. In other words, how does the experimental situation used in BCD evaluations compare with normal viewing conditions? In an earlier investigation[7] involving small sources located at various angular distances above the line of sight, no significant differences were found. Since the present investigation involved much larger sources, it was decided to check this. The ceiling brightness was varied while the observers maintained their line of sight in the direction of the comparison source. The latter, which was not used, was maintained at 20 footlamberts so that it blended with the wall brightness. The mean value of ceiling brightness judged to be at BCD was found to be 305 footlamberts.

This 25 per cent increase in BCD brightness was not unexpected, nor is it inconsistent with the earlier data. When observers are continuously exposed to an extensive luminous area, their adaptation level—or equivalent field brightness—is somewhat higher. Therefore, a higher brightness would be accepted for the BCD sensation. When the sources are small, they do not contribute materially to the field brightness and hence their effect upon BCD would be expected to be negligible.

Such results are not considered to reduce the suitability of the momentary exposure technique for evaluating a given lighting system. In all of our BCD investigations — basic and applied — momentary exposure has been the common method. In other words, a specific lighting system is evaluated in terms of a standard comparison source. Since both are momentarily exposed, they will be influenced to the same extent by the experimental procedure and the relative rating will be unchanged. Unless such a comparison method is used, it would be necessary to rely upon absolute subjective evaluations. Experience has indicated these to be unreliable and most difficult to make. When more detailed information is available on effects such as these, it should be possible to make the necessary allowances for them.

Elements of Luminous Ceiling

Ten different combinations of lengthwise rows were evaluated by the comparison method. The various experimental conditions are listed in the first column of Table III. The total solid angles $\Sigma\omega$, subtended by the various combinations within the average field of view of the group of observers are shown in the second column. The areas ranged from the full luminous ceiling down to a single row of elements. It is obvious that many other combinations of rows could have been included, but it was believed that these ten would provide sufficient information for present purposes. The evaluations were made with constant wall and luminous ceiling element brightnesses of 20 and 300 footlamberts, respectively. The mean values of brightness of the comparison source B_c, which the observers judged

TABLE III—Solid Angles and Subjective Evaluations of the Ten Experimental Conditions.

Experimental Condition	Luminous Area	Comparison Source Brightness	Subjective Rating	Index of Sensation for B_c
	Rows	$\Sigma\omega$ (Ster.)	B_c (fL)	Comp/BCD	M_c
A.	All	0.764	1680	1.14	155
B.	1-3-5-7-9	.403	1475	1.00	136
C.	2-4-6-8	.361	1403	.95	129
D.	1-5-9	.220	1194	.81	110
E.	4-6	.221	1213	.82	112
F.	3-7	.183	964	.65	89
G.	2-8	.140	881	.60	81
H.	5	.118	980	.66	90
I.	3	.0915	825	.56	76
J.	1	.0513	663	.45	61

to produce the same visual sensation as the indicated arrangement of lengthwise rows, are presented in the third column of Table III. As would be expected, these comparison source brightnesses generally decrease as the solid angle of the luminous area decreases. However, it will be noted that B_c for Condition *H* is greater than that found for Conditions *F* and *G*, even though the solid angle subtended by the former is less. This indicates the contribution of the position index which is a measure of the effect of the location of sources in the visual field. The elements included in Condition *H* are located directly forward from the observer, whereas those of Conditions *F* and *G* are located considerably to the side.

Relative subjective ratings can be computed in terms of the ratio of the comparison source brightness to the BCD brightness of the source on the line of sight, *i.e.*, Comp/BCD. The average BCD brightness of the test source, for a wall brightness of 20 footlamberts, was found to be 1480 footlamberts. The ratios Comp/BCD for the ten experimental conditions are shown in the fourth column of Table III. From these, it is seen that Condition *B* was judged to produce a sensation at the borderline between comfort and discomfort.

Another way of expressing the subjective evaluations is in terms of the index of sensation M_c of the comparison source. These values were computed by means of the basic BCD formula

$$M = \frac{B}{P\ F^{0.44}\ (\omega^{-0.21} - 1.28)} \qquad (3)$$

in which *B*, *P* and ω are the brightness, position index and visual size, respectively, of the source and *F* is the field (wall) brightness. In the case of the comparison source, $P = 1$, $\omega = 0.0011$, $F = 20$ and *B* corresponds to B_c. Values of the index of sensation M_c are presented in the last column of Table III. It will be noted that B_c and *M* are directly proportional because of the linear relationship between these factors in Equation (3). Both are presented because each lends itself to certain types of comparisons.

Analyses, Comparisons and Evaluations

The data shown in Table III present some interesting opportunities for developing methods for computing discomfort glare ratings. As has been pointed out, it seems highly desirable to be able to relate such computed ratings to subjective evaluations. Agreement can be indicated by correspondence of the relative order of discomfort produced by the various experimental conditions, or preferably, by a direct proportional relationship between computed and observed values. It is emphasized that the comparison source brightness (B_c), the subjective ratings (Comp/BCD) and the indices of sensation (M_c) are not measures of glare sensation nor do they, by themselves, tell us whether one experimental condition is twice as glaring as another. However, they do represent subjective evaluations of relative discomfort to which computed glare ratings should be relatable.

In reports of previous BCD investigations, a number of methods have been suggested for computing discomfort ratings. They have been applied to practical situations with varying degrees of success. For example, in some cases it was found that unduly high discomfort ratings seemed to be caused by the large number of luminaires. In others, especially luminous ceilings, the number of elements into which the ceiling was arbitrarily subdivided introduced an uncontrollable variable. Practical lighting installations may involve a wide range in sizes and numbers of luminaires, and total luminous areas. Therefore, any universally applicable method must take such things into consideration.

All discomfort glare investigations have emphasized the non-additivity of glare effects. That is, computed evaluations involving two or more sources have indicated greater discomfort than is shown by experimental observations. That additivity probably is a complex function is illustrated by the values of Comp/BCD and M_c of Table IV. For example, the relative rating of Condition *B* is 1.0, which is average BCD. This particular combination of luminous elements is made up of Conditions *D* and *F*, for which the relative ratings are 0.81 and 0.65, respectively. On a purely sensation basis, it can be said that *B* is equal to *D* plus *F*. However, the sum of the ratings Comp/BCD of the latter two conditions is considerably greater than the rating for Condition *B*.

The usual procedure for obtaining discomfort glare ratings for a complete lighting system is to sum up the computed glare ratings of the individual luminaires or luminous elements. These individual ratings can be expressed as indices of sensation *M* computed by means of Equation (3), or as values of *G* by the formulas developed by Harrison and Meaker[8] and by Petherbridge and Hopkinson.[9] They also can be expressed in terms of a function of solid angle ω, such as was suggested by Fry.[5] It is important that the ratings give appropriate weight to the fundamental factors of source brightness, size and position and the field brightness.

When individual indices of sensation *M* are computed, it invariably has been found that the sum exceeds the experimentally determined index of sensation. Furthermore, the discrepancy appears to be a function of the number of luminaires or elements into which the luminous area has been subdivided. This is illustrated by comparing the

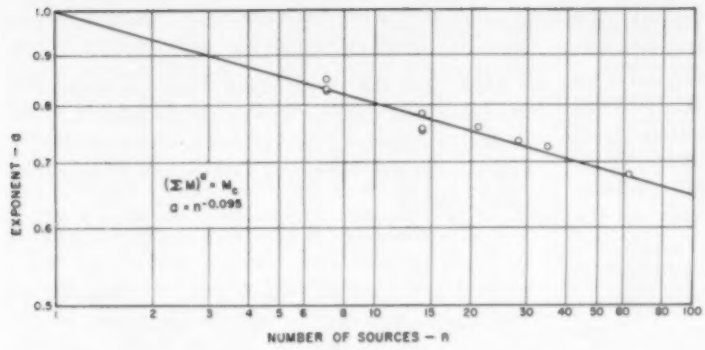

Figure 4. Relationship between exponent "*a*" and number "*n*" of luminous elements included in a group being evaluated. The variable exponent provides a method for relating the sum of the indices of sensation (ΣM) to the experimentally determined subjective evaluation.

computed values ΣM (Table IV) with the experimentally determined indices of sensation M_c (Table III). As the number of elements decreases, the ratio of ΣM to M_c becomes smaller. Obviously, when a single source is involved—as was the case in the original BCD investigations—this ratio becomes unity.

In order to explore the possibility of ΣM being exponentially related to M_c in terms of the number of elements "*n*." Fig. 4 indicates that a linear This is based upon a suggestion recently made by Logan which parallels some of our earlier attempts. Values of the exponent "*a*" have been computed from

$$(\Sigma M)^a = M_c \qquad (4)$$

and plotted as the open circles against the number of elements "*n*." Fig. 4 indicates that a linear logarithmic relationship can be established between "*a*" and "*n*." Using exponents obtained from the curve, values of $(\Sigma M)^a$ have been computed and are shown in Table IV. While the agreement with the subjectively determined M_c is not perfect, this exponential method of dealing with the sum of the individual indices of sensation may have possibilities for use as a practical way of dealing with multiple sources.

When computing ΣM, the luminous areas were arbitrarily divided into specific elements. In order to determine whether this had any influence upon the comparison between experimental and calculated ratings, the full luminous ceiling was subdivided in several different ways. For example, several groups of nine elements were considered as single units and new values of ΣM were computed. In this case, the total number of elements was 39 and the exponent "*a*" from Fig. 4 is 0.715. The summation of M is equal to 1154 and the final value of $(\Sigma M)^a$ equals 155. This is identical to the experimentally determined value of M_c. Other groupings of individual elements resulted in similar good agreement. Thus, this method has the advantage of taking into consideration the arbitrary division of a large luminous area into smaller elements.

Another possible method of dealing with multiple sources is to convert each individual luminous element into an equivalent one located on the line of sight. Such conversions readily can be made by means of Equation (3). By definition the index of sensation of the converted source on the line of sight M_o is identical to that of the corresponding element M_n. Thus,

$$M_o = M_n$$

and, from Equation (3)

$$\frac{B_o}{P_o F^{0.44} (\omega_o{}^{-0.21} - 1.28)} = \frac{B_n}{P_n F^{0.44} (\omega_n{}^{-0.21} - 1.28)} \qquad (5)$$

TABLE IV—Discomfort Glare Ratings as Computed by Various Methods.

Experimental Condition	Sum of Indices of Sensation	Number of Elements	Computed Index of Sensation	Equivalent Source on Line of Sight				Fry Method
				Size	Ratings			
	ΣM	n	$(\Sigma M)^a$	$\Sigma\omega_o$	$\omega_o/\bar{\omega}_o$	$B_o/\bar{B}_o$	M_o	$\omega/\bar{\omega}$
A.	1606	63	152	0.0611	1.73	1.44	154	3.60
B.	865	35	130	.0307	.86	.93	100	1.82
C.	741	28	135	.0305	.87	.92	100	1.78
D.	485	21	110	.0154	.44	.66	72	.90
E.	410	14	109	.0212	.61	.76	83	1.02
F.	379	14	103	.0153	.42	.66	71	.92
G.	331	14	92	.00929	.27	.54	58	.76
H.	198	7	81	.00964	.28	.55	59	.49
I.	190	7	78	.00765	.21	.47	54	.46
J.	144	7	62	.00286	.082	.35	37	.20

Since the most logical factor to add is solid angle, values of ω_o for each element were computed. In this investigation B_n was 300 footlamberts and was taken for B_o; P_o is equal to unity; and P_n and ω_n are the position index and solid angle, respectively, for each ceiling element of the simulated room. Computed values of the sum of the individually converted sources for each experimental condition are presented as $\Sigma\omega_o$ in Table IV. These are the solid angles of the sources on the line of sight, considered equivalent to the group of elements included in the corresponding experimental conditions.

It is evident that these equivalent sizes of sources fall within the range of the areas included in the original BCD investigations. Therefore, they do not impose the problem of doubtful extrapolation in order to apply, for example, Equation (3). Since the position index P_n of the ceiling element is included in the determination of ω_o, these values would seem to be of considerably greater significance than the actual solid angle ω. Furthermore, on a relative basis the values of $\Sigma\omega_o$ agree quite well with the subjective evaluations in Table III.

There are several ways in which $\Sigma\omega_o$ can be used for computing discomfort glare ratings for comparison with one or more of the methods of expressing the subjective evaluations. One is in terms of the ratio, $\omega_o/\bar{\omega}_o$ which is similar to the method suggested by Fry.[5] In this ratio, ω_o is the solid angle required for the same source to produce a sensation at the borderline between comfort and discomfort (BCD). Equation (3) is used for determining $\bar{\omega}_o$ by using a value for M which corresponds to average BCD.

Ratings also can be in terms of $B_o/\bar{B}_o$ in which B_o is the brightness of the equivalent source and $\bar{B}_o$ is the brightness required for the same source to produce the BCD sensation. A third approach could be in terms of M_o which is computed by means of Equation (3) using appropriate values of B_o, F and ω_o. M_o, of course, should be compared with M_c, and the relative ratings $\omega_o/\bar{\omega}_o$ and $B_o/\bar{B}_o$ with Comp/BCD.

Computed values of these ratings are given in Table IV. For the ratios $\omega_o/\bar{\omega}_o$ and $B_o/\bar{B}_o$ computed ratings for condition *A* are higher and for all other conditions are lower than the corresponding values of Comp/BCD. The ratio $B_o/\bar{B}_o$ provides a more nearly direct ratio than $\omega_o/\bar{\omega}_o$. Similarly, M_o agrees quite well with M_c.

Since the relationships between these computed ratings and the subjective evaluations can be represented by straight lines on logarithmic coordinates, they can be related to each other by exponential functions of the form

$$\text{Comp/BCD} = K(\text{Computed Rating})^a$$

Thus,

$$\text{Comp/BCD} = 1.34\ (\omega_o/\bar{\omega}_o)^{0.37} = 1.13\ (B_o/\bar{B}_o)^{0.82}$$

and

$$M_c = 2.75\ M_o^{0.84}$$

These and the preceding method involving ΣM illustrate that dealing with multiple sources is exceedingly complex. Indications are that subjective evaluations and computed ratings can be exponentially related.

It will be of interest to compare ratings computed by Fry's method[5] with those outlined above. In his method, $\omega/\bar{\omega}$ is computed for each luminous element and their sum is considered to be the rating for the entire group. In this case ω is the solid angle subtended by the element and $\bar{\omega}$ is the solid angle required for the same source, acting alone, to produce the BCD sensation. Values of the ratings for each experimental condition are given in the last column of Table IV.

One serious limitation of this method is that some values of $\bar{\omega}$ are indeterminate because of the complex curved relationship between source brightness and solid angle. This is being confirmed by the new work of Hopkinson and Bradley[10] in which data are being obtained for sources of various sizes up to the full visual field. Indications are that, for a given field brightness, the source brightness will be a minimum for some specific value of source size. Smaller and larger sizes of source will permit higher BCD brightnesses. This minimum value of source brightness will prevent computing $\bar{\omega}$ for elements located at considerable distances from the line of sight but which are within the field of view. This was found to be the case for those elements in the crosswise row (Fig. 3) nearest the observer. These elements had to be excluded from $\omega/\bar{\omega}$, which then, for all conditions was smaller than it should have been. Using this method of converted sources $(\omega_o/\bar{\omega}_o)$ eliminates this limitation, as do the other methods outlined in this paper.

In a previous investigation[1] with actual luminaires, computed and observed ratings were in good agreement. In the present investigation some of the conditions included considerably larger total luminous areas and more elements than had been studied previously. It was found that the Fry method gave results which, in terms of absolute values, did not agree with the subjective evaluations. This is evident by comparing $\omega/\bar{\omega}$ (Table IV) with Comp/BCD (Table III).

When a rating is in terms of a ratio, such as $\omega/\bar{\omega}$ and $\omega_o/\bar{\omega}_o$, its value must be unity when the condition produces the average BCD sensation. If this were not the case, such methods would not be applicable even to the basic BCD data. The computed ratings $\omega/\bar{\omega}$ predict that Condition *B* would be relatively uncomfortable, whereas the average subjec-

tive evaluation was at the borderline between comfort and discomfort. On a relative basis, $\omega/\bar{\omega}$ provides ratings which agree with Comp/BCD. However, unless a reference basis can be determined, it is difficult to assign any useful meaning to these ratings. It appears that the large number of individual luminous elements included in some of the conditions may have a considerable effect upon such computed ratings.

Conclusion

As has been the case in most investigations concerning discomfort glare, each experiment seems to raise more questions than it answers. These new data include subjective evaluations of large luminous areas in a visual environment which corresponds to those found in practice. A number of approaches have been outlined for computing discomfort glare ratings. Time and space have not permitted obtaining as many data or making as many analyses as are desirable. Therefore, this paper should be considered as a report of progress on the very complex subject of discomfort glare and not as presenting a new preferred method for dealing with the subject.

It is hoped that by presenting this information for consideration by those who are interested in these problems, discussion and further analyses will be stimulated. Some may feel that the complexities of discomfort glare are too discouraging. However, it remains an important problem in lighting practice. The application of empirically derived methods in this country and abroad have indicated certain limitations. Investigations of the type reported in this paper should help put us in a better position to develop a universally applicable method for dealing with discomfort glare, especially with those aspects which involve large luminous areas or many luminous elements.

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DISCUSSION

R. D. BRADLEY:* This paper contains much worthwhile information pointing up several facets of this subject, some fairly bright, others more obscure. The authors have worked with basic research, double checking the purely theoretical situation by placing it in an actual working condition. They stress that while there are several approaches to a system, the system must be workable in the field to have accomplished its mission.

There are a few points which I would like to have clarified. Do the authors feel that 12 observers, although they are trained observers, are a sufficiently large cross-section to be representative? Allphin's data[1] using 109 inexperienced observers seems to lead to some conclusions which are diametrically opposite to those pointed out in this paper. The authors state that with their experienced observers, the glare tolerance level seemed to be raised by about 18 per cent. While Allphin does not state the number of trained observers, he does state that "engineers chose substantially lower brightnesses than did inexperienced observers." The two test methods may pose some problem of correlation, although the authors seem to point out that the momentary exposure system is compatible with subjective appraisal. Then, there is always the question as to when an "inexperienced observer becomes educated" and starts making sophisticated judgments.

The authors touch on a very important phase of glare appraisal—adaptation level. This is a very obvious variable which must be accounted for, yet relatively few workers in this field seems to stress this variable. One of the systems in current use assumes that anything from around 24 footlamberts to over 100 footlamberts is the same. Actual experience will immediately point out the fallacy of such an assumption even if no theory were propounded. The authors have set up a typical office situation and I wonder if they would comment on what differences might occur if an office worker looked up from a desk task of 80 footlamberts and momentarily glanced at the wall brightness of 20 footlamberts. Here the adaptation level would be that of the task, and the "heads up" position would be that of relaxation rather than one of concentration.

The popular approaches in the past have been the "fixture" approach, making the assumption that all other factors were favorable and that the only variable was the brightness of the fixture. This assumption could be valid and yet be rather impractical as normal field applications involve more complex brightness and postural patterns. In spite of the existing fetish for simplicity, this rather complex subject should have enough variables to make it practical in everyday application. The authors have done exploration along this line by using their actual room conditions. Their findings confirm some of their previous work; however, I wonder if they feel that this should be carried one step further, using actual office tasks to create adaptation level.

I believe that an IES system could be developed with the

*Day-Brite Lighting, Inc., St. Louis, Mo.

knowledge presently available. Although there are some minor differences of opinion, most researchers are in agreement as to basic concept and formulation. The time has passed when we should attempt to appraise glare situations by rule of thumb methods or all-inclusive go-no-go, hinged-axis curves. A true system of appraisal should give intelligible numerical engineering information that could be used by the engineering profession and/or the interested public.

1. Allphin, Willard: "BCD Appraisals of Luminaire Brightness in a Simulated Office," ILLUMINATING ENGINEERING, Vol. LVI, No. 1, pp. 31-44 (January, 1961).

WILLARD ALLPHIN:* The authors have made another interesting contribution to the growing literature on discomfort glare. Naturally, in the light of my paper,[1] I cannot agree with their statement: "Unless such a comparison method is used, it would be necessary to rely upon absolute subjective evaluations. Experience has indicated these to be unreliable and most difficult to make."

Because our Ipswich work seems to have produced meaningful results, and the authors of this paper are offering a method for adding indices of sensation, I have applied their method to our data. The index of sensation, M, was calculated by their formula (3) for each luminaire in one of our situations and then these indices were combined according to the exponential formula of their Fig. 4. Fig. A shows the results of applying this formula to our six situations when each situation is at median BCD brightness. The agreement seems quite interesting.

*Sylvania Lighting Products, Salem, Mass.

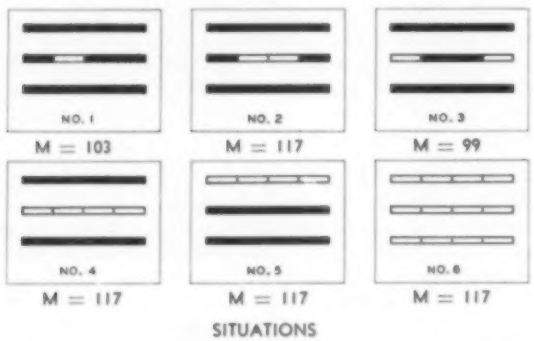

Figure A. Computed indices of sensation, M, for median BCD brightness of Ipswich situations.[1]

Dr. Glenn Fry in the paper, "The Evaluation of Discomfort Glare,"[2] relates index of sensation M to Harrison-Meaker Glare Rating, G in his Fig. 3 (shown as Fig. C here). As long as both G and M were based upon the same elements, a curve such as this could be developed to relate them to one another. However, Meaker and Oetting have more recently added another element to the glare formula: the brightness of the ceiling or wall near the luminaire. Since this element does not appear in the formula for index of sensation, the exact relationships defined in Fry's Fig. 3 are lost. However, for situations in which the contrasts are not extreme, the agreement should be fairly good.

In the Harrison-Meaker-Oetting method, G's of individual glare sources are added to get the G of the system, but in the Guth-McNelis method, M's cannot be added directly to get the M of the system. One could translate each individual M into a G through Fry's Fig. 3, add the G's and then translate the total G back into an M. This would be somewhat laborious and might invite errors. It is easier to brush up on logarithms and use the new Guth-McNelis formula.

The upper curve M in Fig. B shows the index of sensation at median BCD for each of our situations. The lower curve G gives glare rating for the same conditions. The dashed line M_G is obtained by translating the glare ratings into indices of sensation through Fry's Fig. 3. M and M_G cannot be expected to agree exactly because of difference in bases mentioned above. However, the agreement seems reasonably good.

Summarizing, and referring again to Fig. B, the Ipswich situations are all at median BCD, where 50 per cent of a large group would be comfortable. The G values are glare ratings arrived at by adding the G's of individual luminaires. The M values are indices of sensation, obtained by combining the M's of individual luminaires through the exponential formula of Guth and McNelis. The M_G values are translated from the G values by means of Fry's Fig. 3. One must conclude, it seems, that the exponential formula will be a useful tool.

1. Allphin, Willard: "BCD Appraisals of Luminaire Brightness in a Simulated Office," ILLUMINATING ENGINEERING, Vol. LVI, No. 1, pp. 31-44 (January, 1961).
2. Fry, Glenn A.: "The Evaluation of Discomfort Glare," ILLUMINATING ENGINEERING, Vol. LI, No. 11, pp. 722-728 (November, 1956).

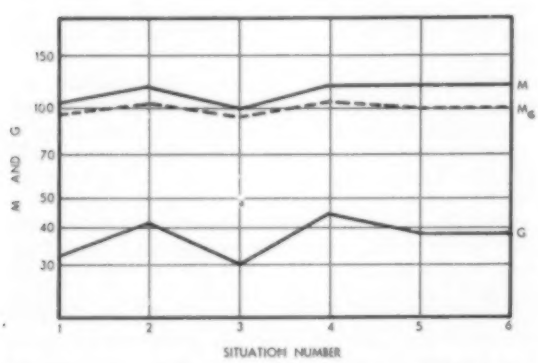

Figure B. Ipswich situations[1] at median BCD brightnesses. M, Index of sensation computed by exponential formula; G, Glare Rating; M_G, Converted from G by curve in Fig. C.

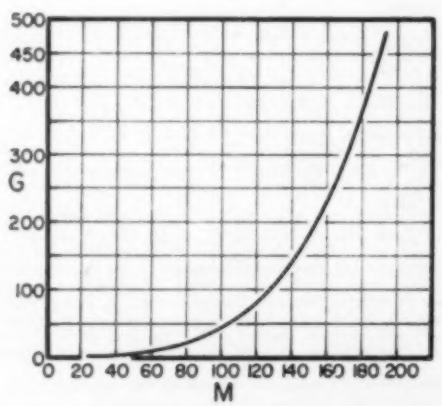

Figure C. Relation between G and M,[2] from Fig. 3 of Fry, Glenn A.: "The Evaluation of Discomfort Glare."[2]

WARD HARRISON:* The authors have described a considerably simplified experimental set-up for the quantitative determination of direct discomfort glare. I am happy to know that they also plan to check individual units and crosswise rows of units. I believe that the same idea could be extended, advantageously, to simulate other types of equipment such as, for example, the shallow rectangular fluorescent diffusers extending three to six inches below the ceiling, which are very popular now.

I am interested in the straight line plot of Fig. 4. Since it is generally accepted that the glare caused by light sources depends upon their location in the field of view, wouldn't one be justified in correcting for this factor before making the plot?

On the fifth page of the paper, the authors have very properly pointed out that you cannot add the subjective ratings of glare. As they have shown, *D* and *F* equal *B*, but the subjective rating of the first two, .81 and .65, add up to 1.45, whereas the actual rating of *B* is 1.00. Experience has indicated, however, that in many cases glare factors can be added; glare factors vary as the square of the subjective ratings. If you square .81 and .65 and add the squares, you have really added glare factors and the sum is 1.076. To get the subjective rating of *D* and *F* together, take the square root of 1.076 which is 1.03. This figure is in very good agreement with the measured value of 1.00. A similar result is obtained when the value for *C* is computed in the same way from its components *E* and *G*.

In Australia, Dr. Dressler and his associates have run tests which corroborated the reasonableness of glare factors and they are now used as a basis for the government lighting code. The research laboratory of one large organization in England was at first skeptical of glare ratings, but has now adopted the idea wholeheartedly. Henry Logan has developed VCF, a somewhat similar system which has some interesting features. As indicated in Mr. Allphin's paper,[1] this gives somewhat more rigorous results.

It seems that real progress in glare evaluation is being made; on a comprehensive basis by Dr. Guth's researches, and in simple form, for many applications, by glare ratings.

1. Allphin, Willard: "BCD Appraisals of Luminaire Brightness in a Simulated Office," ILLUMINATING ENGINEERING, Vol. LVI, No. 1, pp. 31-44 (January, 1961).

H. L. LOGAN:** The more the various components of visual comfort evaluation are unraveled, the more complex their relationships appear. This includes the basic BCD datum shifts with various changes in the stimulus components which the authors glance at, commenting, "Smaller and larger sizes of source [than the minimum source for a given field brightness] will permit higher BCD brightnesses."

However, this uncertainty is to be expected in dealing with the relationships of people to things. It is possible to determine the relationship of things to things with a high degree of accuracy, but the relations of people to things can only be determined approximately. For example, the relations of the earth, sun and moon are so systematic that the exact instant for the start of an eclipse of the sun by the moon can be predicted with virtually no possibility of error, and exact physical "laws" can be formulated to express these relationships.

With the relation of things to people, such as the effect of direct glare, no exact, invariant relationship exists to be discovered. The reactions of people diverge nonsystematically, so they can only be treated statistically, *i.e.*, it is only possible to discover a frequency of occurrence, from which each concrete instance will diverge nonsystematically.

Therefore, common sense, rather than classifical scientific methods, has to be applied in developing a workable technique of visual comfort prediction. At the present time, and for a long time to come, the laboratory data will be insufficient to qualify as a completely satisfactory statistical base. On the other hand, they represent something much better than the only alternative—an individual guess. Every item added to the data reinforces their value, and what the authors have added in this paper can be very helpful.

Further, the development of the exponential relationship between Σ_M and M_c substantially reduces the major source of divergence between computed prediction and observed response. I therefore believe that this paper plus the recent paper by Willard Allphin[1] brings us to the point where a workable method for predicting visual comfort can be set up at a level of approximation that will be useful in present-day American lighting practice.

1. Allphin, Willard: "BCD Appraisals of Luminaire Brightness in a Simulated Office," ILLUMINATING ENGINEERING, Vol. LVI, No. 1, pp. 31-44 (January, 1961).

R. G. HOPKINSON AND P. PETHERBRIDGE:* The problem of additivity of the glaring effects from a number of sources is perhaps the most pressing one facing research workers and engineers in this field, now that the first order effects of glare discomfort are fairly completely understood. Thanks to the work of the C.I.E. Expert Committee, under Dr. Guth's chairmanship, there is basic agreement throughout the world on the major parameters which govern glare discomfort. On the question of the additivity of glare effects, while it is realized that simple additivity is sufficiently precise for a great many practical calculations, it is easily recognized by research workers from the many simple situations where such simple additivity does not occur. Some of these situations were dealt with in some detail in a paper presented at the 1956 IERI Symposium.[1] Valuable papers on the subject have also been contributed by Professor R. C. Putnam of the Case Institute of Technology, and Dr. Guth.

These papers all make a useful addition to our knowledge, but it is clear that the next task of the C.I.E. Expert Committee is to bring all these results together in a form useful to the lighting engineer. We at Garston have found, as was reported in 1956, that under some conditions the glaring effects of multiple sources add up to have a greater effect in practice than is indicated by calculation (we call this super-additivity), whereas in other situations the glare experienced in practice is less than would be indicated by calculation (we call this sub-additivity). In our experience, particularly in industrial lighting, the super-additivity effect can be quite marked; that is, to the extent of one-half a criterion step on our subjective judgment scale. This is still a second-order effect, of course, but now that engineers have confidence in the system of glare evaluation they are becoming sensitive to differences of this order. As we understand this paper, the authors are assuming that sub-additivity will always apply. We believe that this is just an accident of their experimental conditions and that if they investigate, particularly sources of high brightness in the peripheral field, they will find super-additivity just as Professor Putnam and we did.

Of course, we do not agree that absolute subjective evaluations are unreliable and most difficult to make, but we

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**Holophane Co., Inc., New York, N. Y.

*Building Research Station, Garston, Watford, England.

think it is unlikely that the authors do either. Comparison methods have their special value in certain experiments as do absolute evaluations.

It is hoped that, eventually, the work now being conducted at Cornell University will provide additional information on the effects of glare from large sources, and so serve as a comparison with the data being accumulated by the authors.

1. Hopkinson, R. G.: "Researches in England and Abroad," a paper presented at Illuminating Engineering Research Institute Symposium, September 13-15, 1956, Cornell University, Ithaca, N. Y.

S. K. GUTH AND J. F. MCNELIS:* Everyone seems to agree that discomfort glare is a complex subject with very few simple answers to the many questions which arise.

Perhaps we did not make ourselves clear when we stated that experience has indicated absolute subjective evaluations to be unreliable and most difficult to make. We did not mean to infer that evaluations such as those used by Hopkinson and Petherbridge and by Allphin are unreliable. If this were true, we would not have used a similar procedure in many of our own investigations, including the present one. We were referring to a situation in which, for example, an observer enters a room and is required to evaluate the discomfort glare produced by the lighting system in terms of some arbitrary scale, without the opportunity for varying one of the parameters. Most observers are able to indicate whether or not the luminaires are uncomfortably bright, but find it practically impossible to specify the degree of discomfort or acceptability of the situation. They even may be able to qualify their evaluations with adjectives such as "very," "somewhat," "slightly," etc., but such qualitative ratings do not provide information upon which a glare rating formula can be based.

In our opinion, the techniques used by most of the investigators *do* involve comparison methods. That is, an observer can compare successive presentations of, or changes in, one of the factors. Thus, Mr. Allphin's observers adjusted the luminaire brightness for the BCD sensation; each value of brightness was compared with the immediately preceding one. Dr. Hopkinson has used a similar procedure. By giving observers the opportunity for making such successive comparisons, they are able to arrive at values of the experimental variable which can be used for developing a discomfort glare formula.

Mr. Bradley's question about the adequacy of 12 observers has been asked many times. We believe that most investigators will agree that a relatively small group of observers can provide extremely useful and valid information regarding the relationships among the factors involved. This has been stressed in several of our previous papers. Obviously, absolute values obtained by, for example, two small groups may not agree. However, if experimental conditions and procedures are identical, one should expect that the fundamental relationships will also be identical. This is illustrated by the parallelism of the plots between field brightness and BCD brightness (Fig. 1 of the paper) for our original discomfort glare experiment and the present investigation. It is particularly significant that the exponent of field brightness F, as indicated by the slope of the lines in Fig. 1, was found to be the same for several different groups of observers.

On the other hand, data from large groups of observers are needed in order to determine the significance of absolute values. Only in this way will it be possible to develop a meaningful expression for discomfort glare ratings, such as a Visual Comfort Index. We have obtained data with several groups of 50 observers and the new results reported by Mr. Allphin contribute materially to the available information on subjective differences.

We do not agree with Mr. Bradley that Mr. Allphin's data using inexperienced observers "seem to lead to some conclusions which are diametrically opposed to those pointed out by the authors." We have never found a consistent difference between naive observers and those who are experienced in lighting. This may be due, in part, to our experimental procedure which involves comparisons with a "standard" source. There are fewer clues which can be influenced by individual bias or preference based upon experience. However, we have found differences between large groups which could merely indicate that the population samples were not identical. In terms of average values, the Allphin data are in excellent agreement with ours. The main difference is in the spread; some of Allphin's observers selected what appear to be inordinately low and high BCD brightnesses. Nevertheless, comparing his probability function with a recent one of ours, we find that to satisfy 90 per cent of the observers, Allphin's group indicated 25 per cent of the average BCD brightness would be acceptable; our group selected about 30 per cent of average BCD. For the range of 50 to 95 per cent of observers, the relative brightnesses for the BCD sensation are in general agreement. In other words, subjective ratings in terms of a Visual Comfort Index type of scale would not be markedly different.

When does an inexperienced observer become educated and make sophisticated judgments? This question of Mr. Bradley's is one which we have asked ourselves many times during the course of our experiments. A precise answer has eluded us. In the initial phase of our investigations, which began in 1946, our observers were considered naive regarding the experimental procedure. Ten of the group continued as observers over an eight-year period, thus gaining considerable experience, but their average judgments remained relatively constant. The only change was in the variance, which showed considerable improvement.

The matter of adaptation level—or as we prefer to term it, field brightness—raised by Mr. Bradley is very important. Several approaches have been suggested—task brightness, wall brightness, and average brightness of the field of view (with and without the luminaires). What is needed is a numerical value which, when used in the glare formula, will yield an accurate discomfort glare rating of the environment. Furthermore, this numerical value should be easily determined. For this reason, most investigators have used either task or wall brightness. Consideration is presently being given to using the average brightness of the visual field or, at least, some value proportional to it. Until some additional experiments are conducted and analyses made, however, it is impossible to determine whether this will be an improvement.

In the example cited by Mr. Bradley, increasing the field brightness from 20 to 80 footlamberts would reduce our discomfort rating by 30 to 40 per cent, depending upon the luminous area involved. On another basis, to maintain the average BCD sensation, a higher luminaire brightness would be permitted. Such questions regarding field brightness emphasized the need for establishing standardized procedures for computing discomfort glare ratings.

Mr. Allphin's computations using the exponential method of determining the combined effect of several luminaires parallels those presented by Guth in his discussion of Allphin's paper (page 39, January 1961 IE). The excellent agreement between computed and experimental ratings indicates that

*Authors.

this new method has considerable promise, especially when dealing with the wide variety of luminaire combinations encountered in interior lighting practice.

It might be possible to follow Dr. Harrison's suggestion and incorporate a correction for the location of sources (position factor) in the exponential function shown in Fig. 4 of the paper. Of course, this factor already is included in the formula used for determining the index of sensation M for each source or element. There does not seem to be too great an advantage in including it in the effective exponent. Moreover, doing this would require a different exponent for every combination of sources. It could be used only for a standardized layout of luminous elements such as is employed for determining the Harrison-Meaker Glare Factor tables.

We have tried various methods of combining the subjective ratings, as proposed by Dr. Harrison. Sometimes they work, but more often they do not. For example, applying his procedure to Condition D, which is physically equal to $J + H + J$, and to Condition B, equal to $J + I + H + I + J$, we find that a simple power function does not appear to be applicable. It might be possible to determine the power and the root which would relate the evaluations of individual rows to that of the group as a whole. However, it does not seem to lend itself to as ready a solution as the exponential method outlined in the paper.

We should like to emphasize that subjective evaluations are a means to an end. They provide a reference basis for computed ratings. We are searching for the formula and the method of its application which provide the best agreement with subjective evaluations for the greatest range of experimental conditions. The exponential method seems to satisfy this requirement.

The apparent "uncertainty" referred to by Mr. Logan is not as uncertain as it may seem to him. Obviously, all studies of his reactions to and evaluations of environmental factors involve relationships of "people to things." However, the mere fact that the reactions and evaluations are variable should not suggest uncertainty. The statement that smaller and larger sources will permit higher BCD brightnesses has a very simple explanation: when the size of a source is relatively small, it contributes very little to the average field brightness. Therefore, the relationship between area and brightness for the BCD sensation is very straightforward; the smaller the area the greater the permissible brightness. On the other hand, as the source size is increased, it occupies progressively a greater portion of the visual field and contributes more and more to field brightness. It is obvious that when the field brightness increases, the permissible BCD brightness of the source also increases. Thus, we find that the BCD brightness is a minimum for the specific area at which the interrelated effects of source size and field brightness balance each other. That is, up to this point, the dual effects of an increase in area (which requires decreasing source brightness) and an increase in field brightness (produced by increases in area and which permits a higher source brightness) are compensatory. However, as the area is increased beyond this value, its effect upon field brightness becomes greater. When the entire visual field is nearly filled by the source, the peripheral surround has very little effect upon field brightness and the luminous area becomes both the source and the field. Under this condition, the source is judged by itself.

Mr. Logan's statement, "With the relation of things to people, such as the effect of direct glare, no exact, invariant relationship exists to be discovered," is not strictly true. Indeed, there are large differences among individual observers. However, we have found that each observer, by himself, does provide a fairly invariant relationship. When all observers are considered on a relative basis, we find that the net result is, for all practical purposes, invariant. If this were not the case, we would not find that the basic relationships among the factors contributing to discomfort glare are as consistent as they turn out to be from experiment to experiment and from group to group. The differences among people are used in a very practical way for the development of a rational discomfort glare rating scale. This is a *positive* application of variability, and is to be preferred to the usual negative approach in which such variability is used in an effort to illustrate the unreliability of data.

As Dr. Hopkinson and Mr. Petherbridge indicate, we are beginning to arrive at general international agreement on the major parameters which affect discomfort glare. As more data become available, the agreement on the relative effectiveness of these factors is becoming closer. However, the matter of additivity has not been settled. While simple additivity does seem to work in a few limited situations, the fact that it does not do so all the time has stimulated us to investigate it further.

We have never encountered super-additivity in any of our multiple-source experiments. In every case, the subjective rating has been less than the computed rating, which Dr. Hopkinson calls sub-additivity. Of course, all of our work has been concerned with interior lighting conditions. It is possible that super-additivity may exist for the conditions encountered in roadway lighting—lower field brightnesses and smaller sources—but even here this effect may be produced by the specific glare formula employed. For example, the Petherbridge-Hopkinson formula will permit higher brightnesses for small sources than does our BCD formula; conversely, for larger areas, they require somewhat lower source brightnesses. In other words, their formula will underrate small sources and overrate large sources as compared with our formula. Incidentally, a similar effect with small sources has been found to occur with the Harrison-Meaker Glare Factor formula which has made Mr. Meaker reluctant to compute ratings except for lighting systems involving larger luminous areas. With the latter, the Harrison-Meaker formula has been found to provide meaningful ratings.

In this connection, it should be of interest that the fundamental relationships between source brightness and source size as found by Arndt, Bodmann and Muck, by Vermeulen and de Boer, and by us, agree very well. The effective exponent of solid angle ω for the range of source sizes common to the three investigations was found to be about 0.3, as compared with a value of 0.5 found by Petherbridge and Hopkinson. This larger exponent seems to produce computed ratings which, when compared with subjective evaluations, result in super- and sub-additivity.

We do not believe that sub-additivity is "just an accident of our experimental conditions." It seems to us that the new data reported by Allphin refute this. Mr. Allphin used experimental conditions and methods which are very similar to those used in the Petherbridge-Hopkinson investigations. Thus, sub-additivity appears to be the rule rather than the exception.

As Mr. Logan points out, common sense is required in the interpretation and application of all experimental data. We should like to add another requirement—objectivity. Much work on discomfort glare remains to be done. Not until all of it is completed will it be possible to derive the ultimate method for dealing with discomfort glare. Meanwhile, we hope our conclusions indicate at least a modicum of common sense and objectivity.

Here and There with IES Members

Newly-elected IES Fellow in Southern California Section, Philip F. O'Brien (standing, left, in photo at left), who was unable to attend the National Technical Conference in Pittsburgh, receives his Fellow certificate from South Pacific Coast RVP, Roy Kreyser. Seated is Section chairman, Edward Balogh. In photo at right, new Section officers, installed by RVP Kreyser. Standing, l. to. r.: J. Roy Jones, vice-chairman; Edward Balogh, chairman; (Mr. Kreyser and B. J. Hartmann, outgoing chairman) Julius Robertson and E. J. Fraser, board of managers. Seated at head table is guest speaker, Joseph A. Schneller, who discussed "What's New in Ballasts?"

IES General Secretary, J. Dixon Mitchell (right), visits "IES Hall," the principal meeting room of the Atlanta Electrical League in the Architects and Engineers Building of Atlanta. Johnnie Sweatte, chairman of the board of the Electrical League, accompanies Mr. Mitchell on his inspection tour.

Eleven past-chairmen of the IES Milwaukee Section were awarded past-chairman pins at a recent Section meeting. L. to r., photo at left, front row: W. N. Lisch, T. E. Dustin, M. H. Brucsewitz, E. H. Grieb, C. N. Laupp, E. H. Schaefer. Back row: W. C. Kuhnke, R. R. Knoerr, I. L. Illing, E. H. Aik, R. J. Present. Photo at right, incoming chairman, Ed Schnoll (right) receives symbol of office from predecessor Robert Present.

LIGHTING NEWS

Nine Symposiums to Highlight Forum at 3rd National Lighting Exposition, March 5-8

Thirty-two lighting experts from the United States and abroad will participate in a series of nine symposiums on various aspects of current lighting application at the World Lighting Forum, scheduled to be held in conjunction with the 3rd National Lighting Exposition at the New York City Coliseum, March 5-8, 1961. Speakers include representatives from lamp and fixture manufacturers, as well as lighting consultants and officials of interested government agencies. Keynote Address at the Forum will be delivered by IES President Richard G. Slauer.

Registration fee for each of the hour-and-a-half symposiums is $2.00, or $13.50 for the complete series. All seats will be reserved.

Symposium program includes:

MONDAY, MARCH 6

Integration of Lighting, Heating and Air Conditioning

Moderator—Douglas Haskell, *Architectural Forum.*

Speakers—B. S. Benson, Jr., Benjamin Division, Thomas Industries, Inc.; Murray Quin, Day-Brite Lighting, Inc.

Success of New Recommended Footcandle Levels for Office, Industrial and Institutional Areas

Moderator—Henry J. Wald, Wald & Zigas, Consulting Engineers.

Speakers—C. L. Amick, Day-Brite Lighting, Inc.; E. A. Linaday, General Electric Co., Nela Park.

New Light Sources and Their Application

Speakers—A. K. Gaetjens, General Electric Co.; W. S. Till, Westinghouse Lamp Division; T. C. Sargent, Sylvania Lighting Products.

TUESDAY, MARCH 7

Creation of a Comfortable Visual Environment—Quality and Quantity

Moderator—C. L. Crouch, Technical Director, IES.

Speakers—G. W. Clark, Sylvania Lighting Products; H. E. D'Andrade, General Electric Co.; Carl W. Evans, Editor, *Lighting* magazine.

Importance of Adequate Street Lighting

Speakers—Newbold Morris, New York City Parks Commissioner; J. J. O'Neill, Greater New York Safety Council; E. C. Powers, Street and Highway Safety Lighting Bureau; Stacy Standley, Line Material Industries.

Outdoor and Recreational Lighting

Moderator—W. C. Cummings, Public Service Gas & Electric Co., New Jersey.

Speakers—J. R. Chambers, Appleton Electric Co.; Thomas Smith Kelly, Lighting Consultant; W. W. Weld, Revere Electrical Manufacturing Co.

WEDNESDAY, MARCH 8

Residential Lighting

Moderator—Edith B. Evans, *Living for Young Homemakers* magazine.

Speakers—Elizabeth A. Meehan, Philadelphia Electric Co.; Sylvan R. Shemitz, C. S. Mersick Electric Supply Co.

Esthetics of Lighting (Entertainment, Theatre, High School Auditoriums, Art Objects)

Moderator—Robert W. Dowling, City Investing Corp.

Speakers—R. G. Williams, Century Lighting, Inc.; Jean Rosenthal, Theatre Production Service; Joel Rubin, Kliegl Brothers, Lighting.

World Lighting and its Effects

Moderator—Willard C. Brown, Lighting Consultant.

Speakers—Abe H. Feder, Lighting By Feder; Ludovic Gaymard, Chief Electrical Engineer, Paris, France.

The Lighting Exposition will feature approximately 250 exhibits by 200 manufacturers of the latest developments in lighting equipment. There will be no registration fee for the Exposition, which will be open only to the trade, from 1:00 p.m. to 8:00 p.m. on March 5, 6 and 8 and from 1:00 p.m. to 9:00 p.m. on March 7.

The 1960 Exposition, like its two predecessors, is being produced by Harold R. Meyer and sponsored by the Lighting, Lamps and Electrical Manufacturers Salesmen's Association, Inc. Combined attendance for the 1958 and 1959 exposition totaled almost 40,000.

Willis F. Thompson Elected President of Engineering Trustees

The United Engineering Trustees, owners of the United Engineering Center, future home of 18 professional engineering societies, have announced the election of Willis F. Thompson as president. Mr. Thompson, executive vice president of Westcott and Mapes, Inc., New Haven, Conn., and a former vice president of The American Society of Mechanical Engineers, succeeds Andrew Fletcher, chairman of the board of St. Joseph Lead Co., New York. Mr. Fletcher has been named chairman of the United Engineering Trustees Real Estate Committee, a post formerly held by Mr. Thompson.

Also announced by UET were the elections of James F. Fairman, Consolidated Edison Co. of New York and L. C. Kemp, Jr., Texaco, Inc., New York, as vice presidents and Michael L. Haider, Standard

IES COUNCIL members and some of the headquarters staff during the November 17-18 Council meeting at the Barbizon Plaza Hotel, New York City. Seated, center, at head of table is President, Richard G. Slauer.

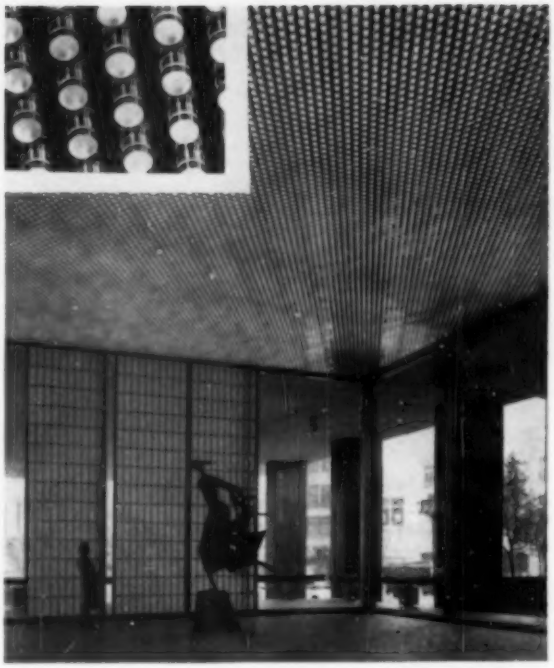
Installations in the News...

Distinctive Lobby Ceiling

Spectacular ceiling in the lobby of the Crown-Zellerbach building in San Francisco is composed of about 16,700 cast acrylic rod plugs (see inset) hung through perforations in 450 highly-polished, diamond-shaped red brass pans measuring approximately 24 inches on each side. Total size of the ceiling is 30 by 52 feet.

The acrylic plugs, two inches long and two inches in diameter, have a square plate of acrylic sheet cemented to their tops to serve as a hanger. Bottom ends of the plugs are sanded to diffuse light from continuous rows of 96-inch slimline fluorescent lamps mounted on 12-inch centers, 12 inches above the brass pans. Since the highly polished sides of the plugs transmit almost no light and the sanded ends "glow," the total effect of the ceiling is an extremely uniform level of transmitted light, with each individual plug having its own brilliance.

Hertzka & Knowles and Skidmore, Owings & Merrill, associated architects, designed the building and the lobby ceiling. Photo and data courtesy of Cadillac Plastic & Chemical Co.



Oil Company of New Jersey, and William H. Wisley, executive secretary of the American Society of Civil Engineers, as trustees.

The United Engineering Trustees, a non-profit organization founded in 1904 following a gift from Andrew Carnegie for the establishment of an engineering center, is composed of the American Society of Civil Engineers, The American Institute of Mining, Metallurgical and Petroleum Engineers, The American Society of Mechanical Engineers, the American Institute of Electrical Engineers and the American Institute of Chemical Engineers.

3 New Fellows Emeritus Elected Bringing Total to 17

At the November 18 meeting of the IES Council in New York City, three Fellows of the Society were elected to the honored Fellow Emeritus grade: G. W. Beals, Connecticut Section; Samuel G. Hibben, New Jersey Section and G. F. Prideaux, Florida Section. In addition, Julius Daniels, New England Section, was elected Member Emeritus.

The honor of Fellow or Member Emeritus is conferred upon those members who are retired from active business or profession and have rendered distinguished service to the Society during their active professional careers.

With the election of the three new Fellows Emeritus, the present total of 17 includes:

CAPITAL SECTION

GIBSON, KASSON S., 4817 Cumberland Ave., Chevy Chase, Md.

CHICAGO SECTION

STAIR, J. L., 1734 E. 72nd St., Chicago, Ill.

TILLSON, EDWIN D., 2507 Lincoln St., Evanston, Ill.

CLEVELAND SECTION

FORSYTHE, W. E., 15006 Terrace Road, East Cleveland, Ohio.

KETCH, JAMES M., 991 Roanoke Road, Cleveland, Ohio.

LUCKIESH, MATTHEW, 21175 Shaker Blvd., Shaker Heights, Ohio.

MAGDSICK, H. H., 159 Van Aken Blvd., Cleveland, Ohio.

WEITZ, C. E., 1848 Hillside Road, East Cleveland, Ohio.

CONNECTICUT SECTION

BEALS, G. W., The Miller Co., Meriden, Conn.

FLORIDA SECTION

DICKERSON, A. F., 1455 Harbor Drive, Sarasota, Fla.

PRIDEAUX, G. F., 528 15th Ave. S., Naples, Fla.

MICHIGAN SECTION

ANDERSON, EARL A., 19218 Berkeley Road, Detroit, Mich.

NEW JERSEY SECTION

HIBBEN, SAMUEL G., 31 Clinton Ave., Montelair, N. J.

NEW YORK SECTION

JAMES, LEONARD V., 9 Forest Lane, Searsdale, N. Y.

LITTLE, WILLIAM F., 75 Dalton Road, Yonkers, N. Y.

PHILADELPHIA SECTION

WESTERMAIER, FRANCIS V., 400 King's Highway East, Haddonfield, N. J.

SOUTHERN CALIFORNIA SECTION

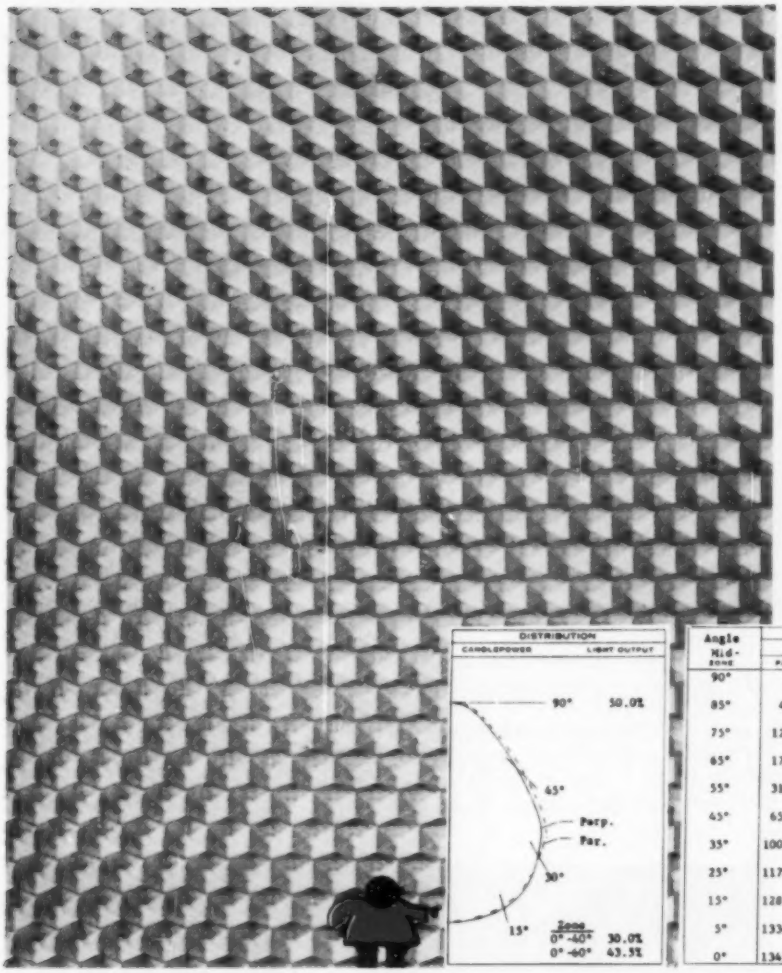
ROLPH, THOMAS W., 1465 San Pasqual St., Pasadena, Calif.

IERI Announces Newsletter Publication

The Illuminating Engineering Research Institute has begun publication of a newsletter, to report highlights of current research projects and news of the IERI administration. Vol. 1, No. 1 of the newsletter, issued in December by the office of the IERI Secretary, notes that Dr. R. G. Hopkinson is now analyzing data in preparation for a formal report on his (with R. C. Bradley of Cornell University) study of large glare sources. Also reported is progress on the Blackwell studies for outdoor illumination levels, now being conducted on a scale-

(Continued on page 12A)

announcing the New EXTRU-LITE® Pattern R-7

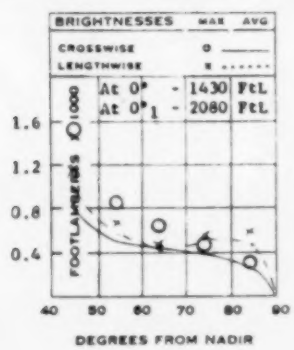


our famous plastic low brightness lensware — NOW extruded in a Brand NEW PATTERN.

Pattern R-7, with optically engineered hexagonal pyramids, permits the light to enter at all angles from the light source. It diffuses and refracts the light onto the work surface with a low brightness that is highly desirable for all types of visual tasks.

This 6-sided prismatic pattern controls, directs and reflects the rays to provide a glareless, more uniform light distribution.

Angle Mid-Zone	MID-ZONE CANDLEPOWER HORIZONTAL ANGLES PAR	22½	45	67½	PERP	LUMENS
90°	0		0		0	-
85°	40.2		40.2		25.3	40
75°	127		125		96.9	125
65°	176		200		179	188
55°	317		313		279	276
45°	653		620		554	472
35°	1003		1000		970	625
25°	1177		1198		1196	551
15°	1281		1293		1301	365
5°	1334		1335		1338	127
0°	1361		1361		1361	-



IMPORTANT! Superior Advantage of Pattern R-7 over other hexagonal shapes: The secret of positive light control is in the *raised prisms*—it's *outstanding* in more ways than one.

Available immediately from stock up to 24" wide in Polystrene or Acrylic.

Write or call our Dept. BK at our Factory for Sample of Extru-Lite R-7 and ETL Report.

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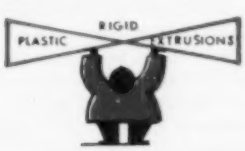

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OUTGOING Ohio Valley Section chairman, Fred B. MacRae (right) accepts certificate of appreciation for his service to the Section from incoming chairman, Harold J. Gruber. Presentation was made at Section's first meeting of 1960-1961 year.

(Continued from page 10A)

model highway for greater flexibility in experimentation with mounting heights, lamp spacings and light distribution patterns.

Changes in the IERI administration include the elections of R. G. Slauer, 1960-1961 IES President, and E. O. George, Detroit Edison Co., as members of the IERI Board of Trustees.

Present plans call for bi-monthly publication of the newsletter, with one research project to be highlighted in each issue. Copies are being sent to all members of the IES Council, Section and Chapter chairmen and secretaries, technical committee chairmen, vice-chairmen and secretaries, Sustaining Members and all contributors to the IERI research fund. Copies may be obtained by writing to C. L. Crouch, Secretary, IERI, 1860 Broadway, New York 23, N. Y.

Engineering Societies Library Reports Increased Use in 1960

The greatest yearly increase in the use of the Engineering Societies Library has been recorded during 1960, according to a recent announcement by library director, Ralph H. Phelps. Requests from all over the world for such services as literature searching, translating, photoprint and microfilm copying increased by 25 per cent over 1959. Telephone requests showed a 35 per cent rise. In all, non-visitor use now constitutes 68 per cent of total library use.

The Engineering Societies Library, now located at 29 West 39th St., New York City, will be relocated in the new United Engineering Center. The library is a department of the United Engineering Trustees. In addition to its collection of books on all phases of engineering, the library subscribes to about 3400 periodicals and other serial publications and is co-sponsor of the Engineering Societies Monograph series.

College-Industry Conference To Study Engineering as a Profession

The development and maintenance of a professional climate in the field of engineering has been chosen as the theme for the 13th Annual College-Industry Conference, scheduled to be held at the University of Cincinnati, February 2-3, 1961.

Sponsored by the Relations with Industry Committee of the American Society for Engineering Education, the conference will consider such problems as the nature and desirability of a professional climate in engineering, means for developing this climate, measurement of professionalism and the importance of a professional attitude to both the individual engineer and the employer. Program topics include: "What a Company Has Done," "What a Consulting Firm Has Done," "What a Government Agency Has Done," "What a University Has Done," and "Professionalism and Unionism."

Two special reports scheduled for presentation at the Conference are the results of a survey on professionalism in industry, conducted for the American Society for Engineering Education by the Opinion Research Corp., and an analysis of the impressions of faculty members during summer employment in industry, which will be presented by the sponsoring committee.

Additional information on the Conference may be obtained from Cornelius Wandmacher, Chairman, College-Industry Conference Committee, University of Cincinnati, 101 Baldwin Hall, Cincinnati 21, Ohio.

Traffic Engineering Fellowships Offered by Yale University

The Bureau of Highway Traffic of Yale University, New Haven, Conn., has announced the availability of fellowships for graduate study in traffic engineering for the 1961-1962 academic year. The $2400-fellowships, to be awarded to qualified graduate engineers who are citizens of the United States, provide $1000 for tuition and a living stipend of $1400, which will be disbursed at the rate of $175 per month for the eight months of the academic year.

In addition to the fellowships, tuition scholarships are available for municipal and state highway engineers who also receive financial aid from their employers in an in-service training program.

The academic program in the Bureau of Highway Traffic includes two full semesters of classroom work, laboratory and individual research, field problems and seminars. Courses available are traffic characteristics and measurements, traffic regulations and control devices, highway planning, highway location and geometric design and highway administration and finance. The Bureau has

(Continued on page 15A)

OFFICERS of Housatonic Chapter, 94th IES local group, at the Chapter's Charter Night meeting in Hamden, Conn. From l. to r.: Walter Damuck, chairman; Russell Benjamin, Daniel Gaidosz, board of managers; Donald Haskell, vice-chairman; John W. Shallenbarger, board of managers; Court Johannsen, secretary. Traditional gavel was sent to the Chapter by the next youngest group, Illini Chapter of Decatur, Ill. Housatonic Chapter, in southern Connecticut, has its headquarters in Bridgeport.

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For many years Holophane technicians have designed visual environments based on sound ILLUMINEERING® principles... These provide prismatically controlled lighting for better seeing—and lighting that expresses the purpose of the space. Other objectives are: illumination to modify appearance of an area, insure safety, and complement structure.

In every case, surround colors are planned to cooperate with the light distribution, to achieve desirable brightness balance and to create an agreeable environment.

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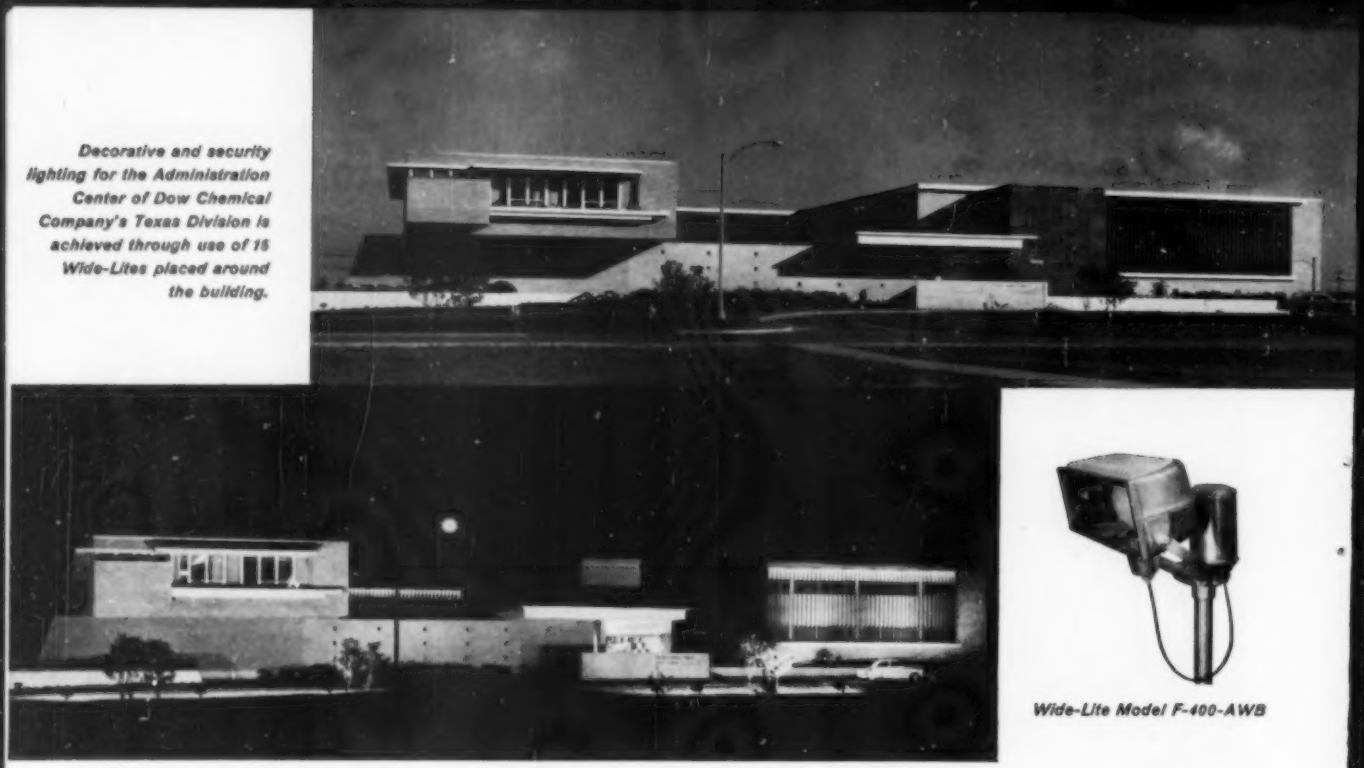

Decorative and security lighting for the Administration Center of Dow Chemical Company's Texas Division is achieved through use of 15 Wide-Lites placed around the building.

Wide-Lite Model F-400-AWB

creative lighting calls for **WIDE-LITE**

Dramatic lighting effects are easily achieved when Wide-Lites are selected as the lighting engineer's basic tool.

Designed especially to enhance the unique characteristics of color-corrected mercury vapor lamps, Wide-Lites bring *new dimension* to decorative lighting. They produce broad patterns which may be overlapped to provide smooth, even coverage without concentric circles, hot spots, or dark shadows to mar the architectural harmony of a building. The patterns are unusually uniform and may be accurately plotted to determine the exact number of units needed to provide any desired illumination level.

Ruggedly constructed from cast aluminum alloy, Wide-Lites are finished in aluminum epoxy paint for corrosion control. All outdoor models are sealed with tempered glass lenses, and relamping is accomplished without disturbing the seal of the lens. Exclusive built-in heat radiating fins limit lamp temperatures to the most efficient range. Sizes range from 100-watt to 1000-watt, and a choice of reflectors is available on all models.

To assist you in planning dramatic decorative lighting effects, Wide-Lite engineers have prepared a unique group of transparencies which read directly in Wide-Lite beam footcandles. Write today for your set . . . and a copy of Catalog 444 which gives information on the complete Wide-Lite line of indoor, outdoor and special application fixtures.

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(*Continued from page* 12A)

graduated approximately 600 professional traffic engineers now in positions with municipal and state highway departments, as well as commercial agencies.

Applications for the fellowships may be obtained from Fred W. Hurd, Director, Bureau of Highway Traffic, Yale University, Strathcona Hall, New Haven, Conn. Deadline for filing applications is March 1, 1961.

Demand for Engineers/Scientists Shows Slight October Rise

The Engineer/Scientist Demand Index, developed by Deutsch & Shea, Inc., technical manpower consultants, reported a 10 per cent increase in the employment demand during the month of October. The increase, which reflects a sharp rise in newspaper classified advertising, may indicate urgency in the search for technical personnel, according to a Deutsch & Shea spokesman.

The Index is based on information supplied by 27 newspapers in major market areas throughout the country, and 16 journals in key technical fields. Three sub-indexes, classified newspaper advertising, display newspaper advertising and technical journal advertising, are combined in order to produce the over-all monthly figure.

During October, the newspaper classified index increased almost 20 per cent, other newspaper advertising rose fractionally and technical journal advertising dropped almost 5 points. Analysis of the data revealed that the classified gain, principal contributor to the overall reported rise, resulted primarily from an increase in size of ads being used.

In the compilation of the Index, data from the 43 participating publications are weighted to compensate for the number of days in the month, number of issues of the publications and other variables.

Obituary

D. Roland Webb, one of the leading IES members in the Maritime area of Canada, died on November 24, 1960 at the age of 47. Mr. Webb joined IES in the early 1930's during his student days at the University of New Brunswick. In 1939, he transferred to associate membership in the Society, and in 1949 was elected to Member grade.

From 1945-1949, Mr. Webb was active as the IES local representative in the Maritime provinces and was the leading force in the establishment of the Maritime Chapter, St. John, N. B., the fourth

(*Continued on page* 16A)

SCHEDULED EVENTS

1961 Dates of Interest to IES Members

January

January 23-26—Plant Maintenance and Engineering Show, International Amphitheatre, Chicago, Ill.

January 24-27—Society of Plastics Engineers, Inc., 17th Annual Technical Conference, Shoreham and Park Sheraton Hotels, Washington, D. C.

January 28-29—National Association of Lighting Maintenance Contractors, Southern Regional Meeting, Birmingham, Ala.

January 29-February 3—American Institute of Electrical Engineers, Winter General Meeting, Hotel Statler, New York, N. Y.

January 31-February 2—National Association of Lighting Maintenance Contractors, Eastern Regional Meeting, Salem, Mass.

February

February 4-5—National Association of Lighting Maintenance Contractors, Midwestern Regional Meeting, Kansas City, Mo.

February 5-11—National Electrical Week.

February 7—National Electrical Week Luncheon, Sheraton-Astor Hotel, New York, N. Y.

February 9—IES Council Meeting, Barbizon Plaza Hotel, New York, N. Y. Members are invited to attend meetings as guests of Council.

February 13-16—American Society of Heating, Refrigerating and Air Conditioning Engineers, Semi-Annual Meeting, Conrad Hilton Hotel, Chicago, Ill.

February 19-22—National Electric Sign Association Convention, Benjamin Franklin Hotel, Philadelphia, Pa.

March

March 2-4—Optical Society of America, Roosevelt Hotel, Pittsburgh, Pa.

March 5-8—Third National Lighting Exposition and World Lighting Forum, New York City Coliseum, New York, N. Y.

March 8-9—National Association of Lighting Maintenance Contractors, Central Regional Meeting, Cleveland, Ohio

March 20-23—Edison Electric Institute, Annual Sales Conference, Edgewater Beach Hotel, Chicago, Ill.

March 21-23—American Power Conference, sponsored by Illinois Institute of Technology, Sherman Hotel, Chicago, Ill.

April

April 8-15—Electrical Home Show, War Memorial Building, Rochester, N. Y.

April 10-11—East Central Regional Conference, IES, Benjamin Franklin Hotel, Philadelphia, Pa.

April 17-18—Southwestern Regional Conference, IES, Skirvin Hotel, Oklahoma City, Okla.

April 20-21—Southeastern/South Central Regional Conference, IES, Biltmore Hotel, Atlanta, Ga.

April 23-28—American Institute of Architects, Annual Convention, Philadelphia, Pa.

April 29-May 3—National Association of Electrical Distributors, Annual Convention, Detroit, Mich.

April 30-May 4—Electrochemical Society Meeting, Claypool Hotel, Indianapolis, Ind.

May

May 1-2—Intermountain Regional Conference, IES, Salt Lake City, Utah.

May 4-5—South Pacific Coast Regional Conference, IES, Sacramento Inn, Sacramento, Calif.

May 8-9—Pacific Northwest Regional Conference, IES, Harrison Hot Springs, Harrison, B. C.

May 15-16—Canadian Regional Conference, IES, Queen Elizabeth Hotel, Montreal, Que.

May 22-25—Design Engineering Show, Cobo Hall, Detroit, Mich.

June

June 5-7—Edison Electric Institute, Annual Convention, New York, N. Y.

June 5-9—Society of the Plastics Industry, National Conference, Commodore Hotel, New York, N. Y.

June 7—IES Council Meeting, Barbizon Plaza Hotel, New York, N. Y. Members are invited to attend meetings as guests of Council.

June 8-9—Northeastern Regional Conference, IES, Berkeley-Carteret Hotel, Asbury Park, N. J.

June 18-23—American Institute of Electrical Engineers, Summer General Meeting, Ithaca, N. Y.

June 19-20—Great Lakes Regional Conference, IES, Sheraton-Gibson Hotel, Cincinnati, Ohio.

June 23-28—American Society of Heating, Refrigerating and Air Conditioning Engineers, Annual Meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

July

July 5-8—National Society of Professional Engineers, Annual Meeting, Olympus Hotel, Seattle, Wash.

July 18-20—Western Plant Maintenance Show, Pan Pacific Auditorium, Los Angeles, Calif.

(*Continued from page* 15A)

IES local group in Canada, in 1949. He served as first Chairman of the Chapter. His activities on behalf of IES resulted, eventually, in the organization of the Bluenose Chapter in Halifax, N. S. (1955) and the Northumberland Chapter, Moncton, N. B. (1960).

Mr. Webb was a consulting electrical engineer, by profession, with the Webb Electric Co. in St. John, N. B. In addition to his activities in IES, he was a member of the Engineering Institute of Canada and the Association of Professional Engineers of the Province of New Brunswick.

IES President, R. G. Slauer (seated center) spoke on "Challenge of Lighting to the Electrical Industry" at a joint meeting of the IES Montreal Section and the Electrical Club of Montreal. Shown here with President Slauer are dignitaries of the Section and Electrical Club and official representatives of the Montreal Section's Sustaining Members. Seated, l. to r.: Fred Patterson, secretary, Electrical Club; Mabin Perry, Southern Canada Power Co.; (Mr. Slauer) Charles Morrison, president, Electrical Club; Al Hanley, chairman, Montreal Section. Standing: E. B. Nicolle, BEPCO (Canada) Ltd.; William McCormick, secretary, Montreal Section; Gilles Perron, Quebec Hydro-Electric Commission; Bernard Issenman, Electrolier, Ltd.; A. G. V. Smith, Northern Electric Co., Ltd.; Fred Fulle, Sylvania Electric (Canada) Ltd.; C. H. Talbot, Shawinigan Water and Power Co.; Joseph Thomas, IES Director. Prior to the luncheon meeting, Mr. Slauer was guest of honor at a reception sponsored by the Montreal Section.

ABOUT PEOPLE

(M) denotes Member grade in the Society; (A) signifies an Associate Member.

Elections held at the 34th annual meeting of the National Electrical Manufacturers Association in New York City on November 17 chose **A. D. R. Fraser,** president of the Rome Cable Division, Aluminum Co. of America, Rome, N. Y., as president of the Association. Mr. Fraser served as treasurer of NEMA for the past year. **W. R. Persons,** president of The Emerson Electric Manufacturing Co., St. Louis, Mo., and **A. E. Pringle, II,** president of The Pringle Electrical Manufacturing Co., Philadelphia, Pa., were elected vice-president and treasurer, respectively. The meeting was also the occasion for the presentation of the electrical manufacturing industry's 50-year certificates to **A. M. Callanan,** director and consultant of Walker Brothers, Conshohocken, Pa., and **Fred F. Loock,** president of Allen-Bradley Co., Milwaukee, Wis., in recognition of their respective half centuries of continuous service to the industry. **N. J. MacDonald,** immediate past president of NEMA and president of The Thomas & Betts Co., Elizabeth, N. J., **James Finney Lincoln,** chairman of the board of The Lincoln Electric Co., Cleveland, Ohio and **Everett Morss,** president of Simplex Wire and Cable Co., Cambridge, Mass., each of whom received a McGraw Award, were cited for personal contributions to industry progress.

E. F. Mulligan, Jones Metal Products, West Lafayette, Ohio, was elected president of the RLM Standards Institute, Inc., at the Institute's annual meeting, October 26 and 27. Other officers selected were: vice-president, **A. C. Kendall** (A), Sylvania Electric Products Inc., Salem, Mass.; secretary, **D. E. Worrell,** Quadrangle Manufacturing Co., Chicago, Ill.; treasurer, **D. E. Collins,** Jones Metal Products.

The Drake Manufacturing Co., Chicago, Ill. has announced the election of new officers. **H. Kenneth Foute,** formerly executive vice-president, has been elected president of the company. **Jack Krutek,** former secretary and sales manager, was chosen vice-president in charge of sales and **Melvin Klingenberg** was named secretary of the concern.

The Board of Directors of the Engineers Joint Council has elected **James N. Landis** as president of the organization, a national federation of 21 engineering societies. Mr. Landis is vice-president of the Bechtel Corp., San Francisco, Calif.

The promotion of **W. H. Goff** to the newly-created post of vice-president in charge of manufacturing has been announced by The Phoenix Glass Co., Monaca, Pa. Mr. Goff, president of the Illuminating and Allied Glassware Manufacturers' Association since 1956, held the position of works manager prior to assuming his new responsibilities.

Charles Edison, former Governor of New Jersey and Secretary of the Navy, has retired as a director and chairman of the board of the McGraw-Edison Co., New York City, effective January 1, 1961. Mr. Edison, son of Thomas A. Edison, has been elected honorary chair-

(*Continued on page* 18A)

January 31—Deadline for 1961 Conference Paper Outlines

The IES Papers Committee has set January 31, 1961, as the deadline for submittal of outlines for proposed papers for the 1961 IES National Technical Conference in St. Louis. Outlines should be sent to: Benjamin S. Benson, Jr., Chairman, IES Papers Committee, Benjamin Division, Thomas Industries, Inc., Des Plaines, Ill.

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Its new, compact design was specially developed for this powerful lamp to give you 19% greater, *constant* light out put of 21 lumens per watt . . . and twice the average life of a conventional 500-watt lamp.

That's not all! Now, attractive lighting installations can be made compactly, easily, economically. The special weatherproof unit design also puts light where you want it. Its extremely sharp cutoff—in a rectangular beam spread—eliminates the usual need for beam overlap, yet provides adequate, uniform light for innumerable applications indoors and out.

For increased lighting efficiency in Industry • Commerce • Recreation • Transportation, buy or specify the versatile *Intenso* "Quartzlite 500" . . . ideal for signboards, displays, outdoor sports, building security, mobile equipment, storage areas and many other uses.

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Installations in the News . . .

Quartz Iodine Lamp Lights Football Field

Brush High School athletic field in Cleveland is lighted to a level of 20 footcandles (IES recommendation for Class IV stadiums, seating 5000 spectators) from a system using 64 weather-resistant 1500-watt quartz iodine lamps. Lamps are housed in fixtures specially designed to project a light beam with a narrow vertical and wide horizontal shape, thus directing a greater percentage of light output onto the playing field.

With the new lighting system, illumination levels were doubled, while the number of poles required for fixture mounting was halved. Four poles, two on each side of the field, are used. Photo and data courtesy, General Electric Co., Cleveland, Ohio.

(Continued from page 16A)

man of the company, which he will continue to serve as consultant.

Richard S. Bowles, Jr., color consultant, has announced the opening of offices in New York City. Mr. Bowles specializes in applied color research, practical lighting and paint technology.

The appointment of **Rose M. Coakley** (M) as lighting consultant has been announced by The Superior Electric Co., Bristol, Conn. Miss Coakley, who will be headquartered in Superior's New York office, was formerly a residential lighting consultant associated with Thomas Industries, Inc., Louisville, Ky.

David L. Litten (A) has been named sales manager of the Lighting Division of the Westinghouse Electric Corp., Cleveland, Ohio. In his new position, Mr. Litten will be responsible for coordinating the activities of the company's regional lighting sales managers. Also announced by Westinghouse was the appointment of **Leo V. Rogers** as assistant to the manager of the midwestern region of the Lamp Division. Mr. Rogers, from headquarters in the Westinghouse lamp sales offices in Chicago, Ill., will be responsible for a broad range of sales administration activities relating to the marketing of the company's line of lamps.

Corning Glass Works, Corning, N. Y., has named **William M. Baldwin** as manager of market development for lighting products. Mr. Baldwin, who will direct development of new products and markets in the lighting field, succeeds **Frederick F. Fleischman, Jr.** (A). Mr. Fleischman has been appointed district sales manager of the Pittsburgh, Pa. office of the company's Technical Products Division. The recently-created position of manager of sales service has been assigned to **Robert T. Cahill.**

Leland M. Wallace (M) has joined the Revere Electric Manufacturing Co., Niles, Ill., as manager of street lighting sales, according to an announcement by John A. McDougall, vice-president of the company. Mr. Wallace, who was formerly associated with the Westinghouse Electric Corp., St. Louis, Mo., has served as chairman of the St. Louis Section of IES and as chairman of the Society's Midwestern Regional Conference.

The appointment of **Everett N. DeVault** as manager—manufacturing engineering for the Outdoor Lighting Department of the General Electric Co., Hendersonville, N. C., has been announced by Robert H. Smith, the Department's manager of manufacturing.

The Wakefield Co., Vermilion, Ohio, has named **Jay Johnston** as representative for the Kansas City, Mo. and Kansas areas. Mr. Johnston, who will have headquarters in the Illumination Sales Co. offices in Kansas City, will handle Wakefield's commercial and industrial lighting equipment.

The establishment of a new Wilmington, Del., district sales office for plastic products, to serve the southeastern market, has been announced by the Plastics Division of the Monsanto Chemical Co., Springfield, Mass. **Robert S. Garvie** was appointed as manager of the new office, effective January 1, 1961. Salesmen assigned to the Wilmington office were **Edward F. Capron, Gerard R. Colli, Wlliam J. DeBrule** and **Frank Masterson,** all of whom have had territories in the southeastern states, which were formerly part of the New York district. **Dennis M. Sweeney** has been transferred

(Continued on page 21A)

Nonexistent 400-Watt Sodium Lamp

An error in the caption of Fig. 1 of the Abstract of "Application of Sodium Lamps to Public Lighting," by J. B. de Boer, on page 498 of the September, 1960 issue of IE has caused considerable confusion in the field of sodium lamps. The caption should have referred to 200- and *140*-watt lamps, not 200- and *400*-watt lamps. There is not, of course, a 400-watt sodium lamp.

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3. Lay in acoustical panels on flanges of troffers, spacer bars and wall angles. Insert extruded polystyrene plastic diffusers in troffers. (Other diffusers available.)

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7-3719

DAYTON, OHIO
John A. Becker Co.
Baldwin 4-1071

SYRACUSE, N.Y.
James W. Sorteos
Granite 9-8910

INDIANAPOLIS, IND.
Electrical Equipment Co.
Melrose 2-4376

TULSA, OKLAHOMA
Manufacturers Rep. Co.
Luther 4-2507

RICHMOND, VIRGINIA
Charles C. Laney
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OAKLAND, CALIF.
Robert E. Gordon
Lockhaven 2-5837

CHULA VISTA, CALIF.
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METALCRAFT PRODUCTS CO., INC.

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The twelve foot tall stalactite lighting fixture shown here has 162 twelve volt lamps. It was designed by the Architect and fabricated by Rambusch. The fixture, in common with our whole custom design series, illustrates Rambusch's unique ability to work from an architect's sketch or model with a sensitivity to and an understanding of the design problems involved. Can we assist you with your lighting design problem?

RAMBUSCH LIGHTING

40 WEST 13th ST., NEW YORK 11, N. Y.

(*Continued from page 18A*)

to Wilmington as sales correspondent and **William A. Davis** will be located in Atlanta, Ga., as a sales correspondent reporting to the new office.

Deaths

Erwin S. Mills, Cleveland Section
John B. O'Donnell, Chicago Section
Frank C. Taylor, Rochester Section
Julian L. Wolf, Cleveland Section

NEW MEMBERS

At the meeting of the Board of Examiners on December 12, 1960, in New York City, the following were elected to membership.

CANADIAN REGION

BLUENOSE CHAPTER

No Elections

FOREST CITY (LONDON) CHAPTER

No Elections

GOLDEN WEST CHAPTER

No Elections

HAMILTON CHAPTER

No Elections

MARITIME CHAPTER

No Elections

MONTREAL SECTION

Associate Members:

Deniger, L. R., The Shawinigan Water & Power Co., Terrebonne, Que.
Monet, P. D., Canadian General Electric Co., Montreal, Que.

NORTHUMBERLAND CHAPTER

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Mackay, J. F., J. Fraser Mackay Agencies, Ltd., Parrsboro, N. S.

OTTAWA SECTION

Associate Members:

Hanley, P. A., Brais, Frigon & Hanley, Consulting Engineers, Ottawa, Ont.
Tyne, A. J., Canadian Westinghouse Co. Ltd., Ottawa, Ont.

QUEBEC CHAPTER

No Elections

ST. MAURICE VALLEY CHAPTER

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Simard, C., The Shawinigan Water & Power Co., Shawinigan Falls, Que.

TORONTO SECTION

Associate Member:

Huckstep, J. J., J. A. Wilson Lighting & Display Ltd., Toronto, Ont.

WINNIPEG CHAPTER

No Elections

EAST CENTRAL REGION

CAPITAL SECTION

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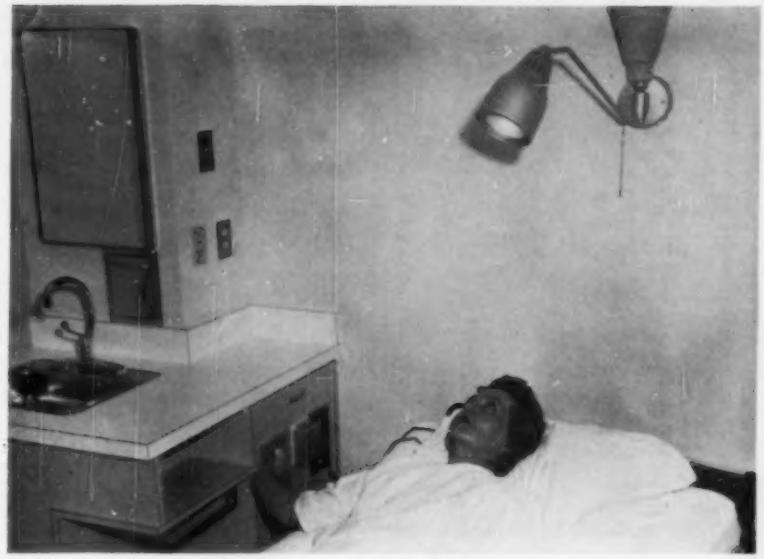
Howton, Lt. Col. H. G., Headquarters, USAF, Pentagon, Washington, D. C.
Hudgins, W. B., Walton Redmile, Bethesda, Md.

EASTERN PENNSYLVANIA SECTION

No Elections

Installations in the News . . .



Hospital Design Fosters Patient Morale

Psychological design of hospital rooms to build patient morale is a specialty of Texas architect, William O'Connell, who believes in providing recovering patients with control over their environmental conditions. At St. Anthony's Hospital in Amarillo, Texas, a specially built bedside unit contains, in addition to closet, dresser space, sink and mirror, a dimmer for adjusting lighting levels, thermostat for control of heat and air conditioning, two-way communication system to the nurses' station and a telephone outlet. Two additional dimmers beside the door to each room permit the entering nurse to adjust the lighting level without disturbing the patient.

Each room at St. Anthony's is decorated with an individual color scheme, with warm, vivid tones dominating the design. Acoustic tile ceilings throughout the hospital keep noise to a minimum. Photo and data courtesy Superior Electric Co., Bristol, Conn.

MARYLAND SECTION

No Elections

PHILADELPHIA SECTION

Associate Member:

Sion, H. F., Perfeclite Co., Philadelphia, Pa.

PITTSBURGH SECTION

No Elections

VIRGINIA SECTION

No Elections

GREAT LAKES REGION

BUCKEYE CHAPTER

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CENTRAL NEW YORK SECTION

No Elections

CLEVELAND SECTION

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Kochevar, R. A., Cleveland Electric Illuminating Co., Cleveland, Ohio.

Student Member:

Fisher, R. B., Fenn College, Cleveland, Ohio.

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No Elections

MIAMI VALLEY SECTION

No Elections

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Fintze, R. J., John C. Virden Co., Cleveland, Ohio.
Holden, W. D., D. H. Brown, Detroit, Mich.

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Associate Members:

Craig, C. H., Craig Electric Co. Ltd., Toledo, Ohio.
Durbin, H., Romanoff Electric Corp., Toledo, Ohio.
Mull, M. H., Toledo Edison Co., Toledo, Ohio.
Russell, C. B., Jones, Henry & Williams, Consulting Engineers, Toledo, Ohio.

OHIO VALLEY SECTION

No Elections

ROCHESTER SECTION

No Elections

WESTERN MICHIGAN SECTION

Associate Members:

Barker, R. L., Hemphill Co., Highland Park, Mich.

(*Continued on page 22A*)

(Continued from page 21A)

Bloink, Mrs. M. H., Purchase Electric Supply Co., N. W. Grand Rapids, Mich.
Edwards, J B., W. Dale Crites & Associates, Haslett, Mich.
Keeler, L. E., Keeler Sales Co., Royal Oak, Mich.
Stratton, C. D., Electric Supply Co., Grand Rapids, Mich.
Walters, N. L., Consumers Power Co., Lansing, Mich.

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Associate Member:

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INTER-MOUNTAIN REGON

ARIZONA SECTION

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Baur, M. H., Arizona Public Service Co., Phoenix, Ariz.

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Associate Member:

Spencer, J. A., Triangle Electric Supply Co., El Paso, Texas.

ROCKY MOUNTAIN SECTION

Associate Member:

Piper, D. E., Sturgeon Electric Co., Inc., Denver, Colo.

SOUTHERN COLORADO CHAPTER

No Elections

UTAH SECTION

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MIDWEST REGION

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McKernan, L. T., Kansas Gas & Electric Co., Independence, Kans.

CORNHUSKER SECTION

No Elections

HEART OF AMERICA SECTION

No Elections

ILLINI CHAPTER

No Elections

IOWA SECTION

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Parish, J. W., Parish & Richardson, Architects, Davenport, Ia.
Roloff, J. A., Interstate Power Co., Clinton, Ia.

OZARK CHAPTER

Associate Member:

Gaines, G. F., Midwest Services, Inc., Joplin, Mo.

ST. LOUIS SECTION

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NORTH CENTRAL REGION

CENTRAL ILLINOIS CHAPTER

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Bussman, W., Crescent Electric Supply Co., Peoria, Ill.
Grimson, F. R., Westinghouse Electric Supply Co., Peoria, Ill.
Sisk, D. L., Graybar Electric Co., Inc., Peoria, Ill.

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Associate Members:

Frankel, A., Westinghouse Electric Corp., Chicago, Ill.
Hamilton, R. C., Jack Riley Associates, Inc., Chicago, Ill.
Jones, J. C., Owens-Corning Fiberglas Corp., Chicago Ill.

INDIANA SECTION

No Elections

MILWAUKEE SECTION

Associate Member:

Bauter, J. S., Edwin F. Guth Co., Milwaukee, Wis.

TWIN CITY SECTION

Associate Members:

Gebhardt, W. L., Northern States Power Co., St. Cloud, Minn.
Olson, H. E., Harris Bros., Minneapolis, Minn.
Thompson, W. H., Cramer Electric Service Co., Minneapolis, Minn.
Williams, J. F., General Electric Lamp Division, Minneapolis, Minn.
Wollan, S. A., Industrial Electric Co., Minneapolis, Minn.

TWIN PORTS CHAPTER

No Elections

NORTHEASTERN REGION

CONNECTICUT SECTION

No Elections

EASTERN NEW YORK SECTION

No Elections

HOUSATONIC CHAPTER

No Elections

NEW ENGLAND SECTION

Associate Member:

Ingraham, A. L., Central Maine Power Co., Augusta, Me.

NEW JERSEY SECTION

Associate Member:

Vogt, T., Radiant Lamp Corp., Newark, N. J.

NEW YORK SECTION

Associate Member:

Daly, W. J., Litecraft Mfg. Co., New York, N. Y.

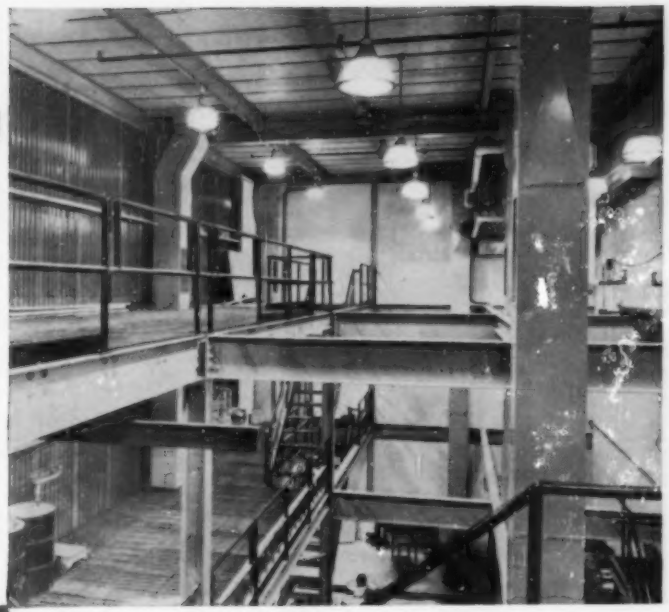
(Continued on page 24A)

1961 IES Regional Conferences

Region	Date and Place	Chairman
East Central	April 10-11 Benjamin Franklin Hotel Philadelphia, Pa.	Ralph R. Enghouser Sylvania Electric Products 4700 Parkside Ave. Philadelphia, Pa.
Southwestern	April 17-18 Skirvin Hotel Oklahoma City, Okla.	Paul R. Sheline Paul R. Sheline Co. 1715 Linwood Blvd. Oklahoma City, Okla.
Southeastern/ South Central	April 20-21 Biltmore Hotel Atlanta, Ga.	Charles R. Minors Georgia Power Co. P. O. Box 1719 Atlanta, Ga.
Inter-Mountain	May 1-2 Salt Lake City, Utah	Donald Dyrenforth General Electric Co. 249 E. 5th South Salt Lake City, Utah Wayne F. Mulcock Utah Power & Light Co. P. O. Box 899 Salt Lake City, Utah
South Pacific Coast	May 4-5 Sacramento Inn Sacramento, Calif.	M. P. Fenton Smoot-Holman Co. 1331 T St. Sacramento, Calif.
Pacific Northwest	May 8-9 Harrison Hot Springs Harrison, B. C.	E. A. Adams Griffon Sales Ltd. 551 W. 8th Ave. Vancouver, B. C.
Canadian	May 15-16 Queen Elizabeth Hotel Montreal, Que.	J. P. Cristel Shawinigan Water & Power 600 Dorchester St. West Montreal, Que.
Northeastern	June 8-9 Berkeley-Carteret Hotel Asbury Park, N. J.	Bruce J. Jensen Public Service Electric & Gas Co. 80 Park Place Newark, N. J.
Great Lakes	June 19-20 Sheraton-Gibson Hotel Cincinnati, Ohio	H. K. Flint 2926 Debreck Ave. Cincinnati, Ohio

LIGHT

exactly where you need it...



Crouse-Hinds Explosion-Proof Lighting Fixtures in Class I, Group D location

Crouse-Hinds Vaportight Lighting Fixtures in a corrosive outdoor location

regardless of surrounding atmosphere!

When there's something in the air — explosive gases, ignitible dusts, corrosive fumes — Crouse-Hinds has exactly the light to give you lighting exactly where you need it — with complete safety!

Lighting that's safe to operate in explosive concentrations of acetylene . . . hydrogen . . . gasoline vapors . . . organic, inorganic or metallic dusts. Lighting that stands up under the corrosive attack of acids, salts, alkalis.

What *kind* of lighting do you need: Bench . . . area . . . flood? Incandescent . . . fluorescent . . . mercury vapor? Permanent . . . portable?

You'll find them all in the Crouse-Hinds catalog. It's the *only* place you'll find lighting for every Class and Group under the National Electrical Code.

Ask your Crouse-Hinds Distributor.

Crouse-Hinds Dust-Ignition-Proof Lighting Fixtures in grain elevator — a Class II, Group G location

CROUSE HINDS
SYRACUSE / NEW YORK

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Crouse-Hinds of Canada, Ltd., Toronto, Ont. Domex, Mexico City, D.F. Peterco, Sao Paulo, Brazil

Installations in the News . . .

A Look at the Future

1961 Hotel Room of Tomorrow, exhibited at the recent National Hotel Exposition in New York City, was designed by Marion Heuer, AID, to provide maximum convenience for guests, minimum maintenance for hotel/motel operators. The rectangular room, 20 by 26 feet including terrace, bathroom and foyer, is divided into separate areas for eating, sleeping, entertaining and working and is furnished with easily-maintained man-made materials. A combination bed-dresser-room divider unit, triangular desk set into a corner, kitchenette and bathroom located back-to-back to share plumbing system, are among the space- and money-saving techniques used. Automation includes a direct dial phone system for inside and outside the building (to reduce switchboard staff), thermostatically-controlled valet unit with built-in steam iron and ironing board, self-replenishing ice supply and dimmer controls for all lighting.

The lighting design features recessed downlights for general illumination, a decorative, three-unit fixture over the dining table, a well-placed floor lamp for reading, surface-mounted fluorescent unit with wood trim in the kitchenette and both overhead and mirror lighting in the bathroom. The decorative wall panel (photo at right) becomes a headboard for the extended sofa bed and the wall bracket above supplies illumination for comfortable reading in bed.

(*Continued from page 22A*)

YANKEE SECTION

Associate Member:

Pensivy, J. L., Pensivy Electric Service & Son, Pittsfield, Mass.

PACIFIC NOTHWEST REGION

BRITISH COLUMBIA SECTION

No Elections

CHINOOK CHAPTER

No Elections

EDMONTON SECTION

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Fulkerth, W. J., Bruce Robinson Electric Ltd., Edmonton, Alta.

INLAND EMPIRE CHAPTER

Associate Members:

Fix, W. C., Columbia Electric & Mfg. Co., Spokane, Wash.

Henderson, K. L., Columbia Electric & Mfg. Co., Spokane, Wash.

OREGON SECTION

No Elections

PUGET SOUND SECTION

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Samson, R. S., City of Anchorage, Anchorage, Alaska.

VANCOUVER ISLAND CHAPTER

Associate Member:

Carlson, S. G., Electrical Service League of British Columbia, Victoria, B. C.

SOUTH CENTRAL REGION

ALABAMA SECTION

No Elections

ARKANSAS CHAPTER

No Elections

GULF COAST CHAPTER

No Elections

MID-SOUTH CHAPTER

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Maxwell, T. M., Westinghouse Electric Corp., Memphis, Tenn.

Student Member:

Du Hon, R., Southern College of Optometry, Memphis, Tenn.

MISSISSIPPI CHAPTER

Associate Member:

Selman, F. R., City of Jackson, Jackson, Miss.

NEW ORLEANS SECTION

Associate Member:

Fisher, L. R., Interstate Electric Co., New Orleans, La.

TENNESSEE VALLEY CHAPTER

No Elections

SOUTHEASTERN REGION

CENTRAL FLORIDA CHAPTER

No Elections

COASTAL EMPIRE CHAPTER

No Elections

FLORIDA SECTION

No Elections

GEORGIA SECTION

No Elections

PALMETTO SECTION

No Elections

SOUTHEAST FLORIDA SECTION

No Elections

SUWANNEE RIVER CHAPTER

No Elections

TAR HEEL SECTION

No Elections

SOUTH PACIFIC COAST REGION

ARROWHEAD CHAPTER

Associate Members:

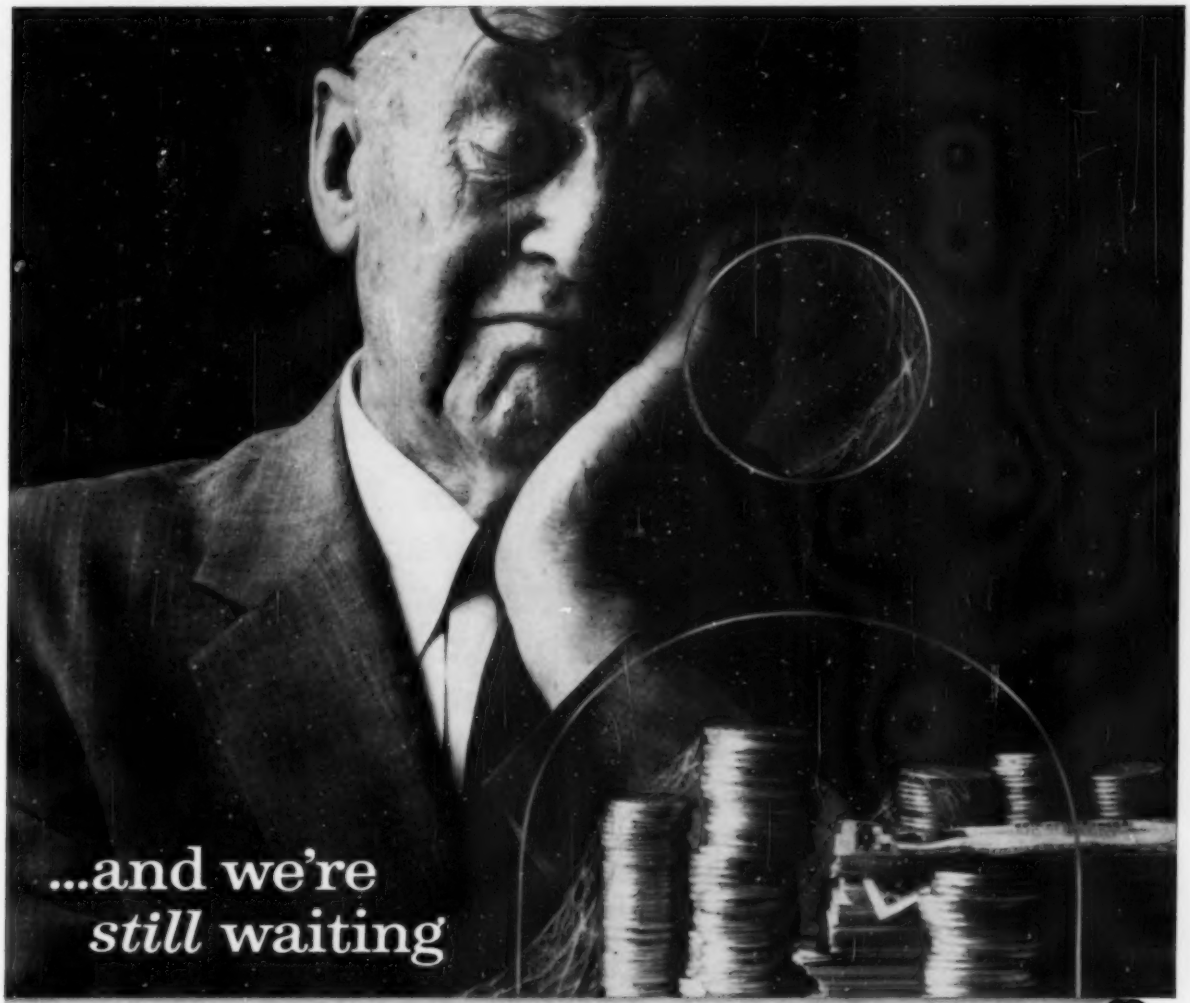
Everson, K. R., Westinghouse Electric Supply Co., San Bernardino, Calif.

Kiefer, C. E., California Electric Power Co., San Bernardino, Calif.

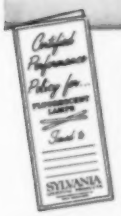
DIABLO SECTION

No Elections

(*Continued on page 36A*)



to give you your money back



Have *you* read the Sylvania guarantee?

"If at any time a Sylvania Fluorescent Lamp fails in your opinion to provide better performance than any other brand fluorescent lamps, on the basis of uniformity of performance, uniformity of appearance, maintained brightness and life, it may be returned to the supplier for *full refund of purchase price.*"

(Only Sylvania dares to back its fluorescent lamps with anything like this remarkable Certified Performance Policy.)

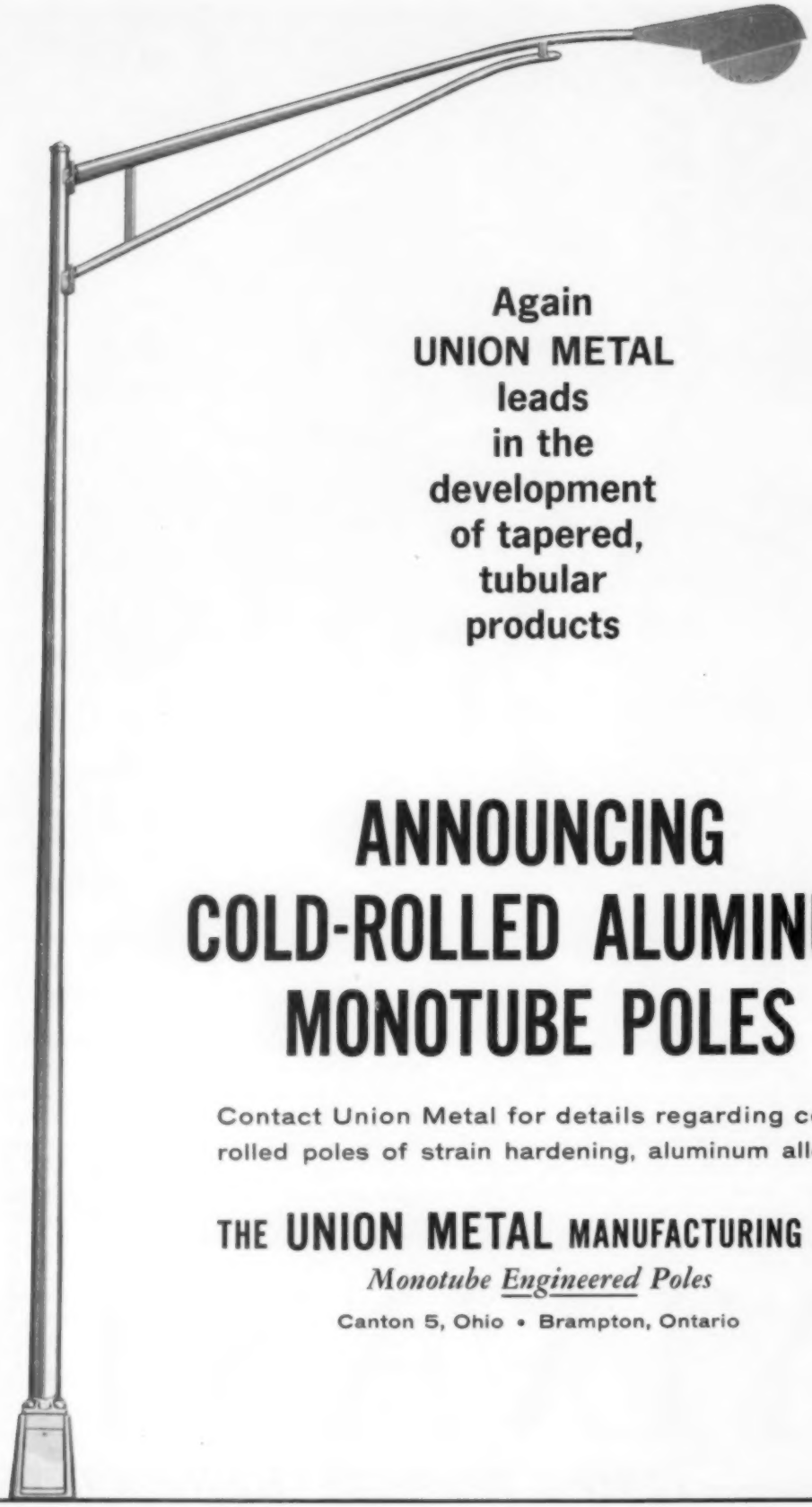
This guarantee of quality is your assurance, too, that Sylvania actually lowers your TCL (Total Cost of Lighting), which means cost of lamps *plus* power *plus* maintenance.

Want better light? Want to be *sure* you're buying it? Call your Sylvania representative. Or write us:

Lighting Division, Sylvania Electric Products Inc., Dept. 61, 60 Boston St., Salem, Mass. In Canada: Sylvania Electric (Canada) Ltd., Montreal.

SYLVANIA

Subsidiary of **GENERAL TELEPHONE & ELECTRONICS**



Again
UNION METAL
leads
in the
development
of tapered,
tubular
products

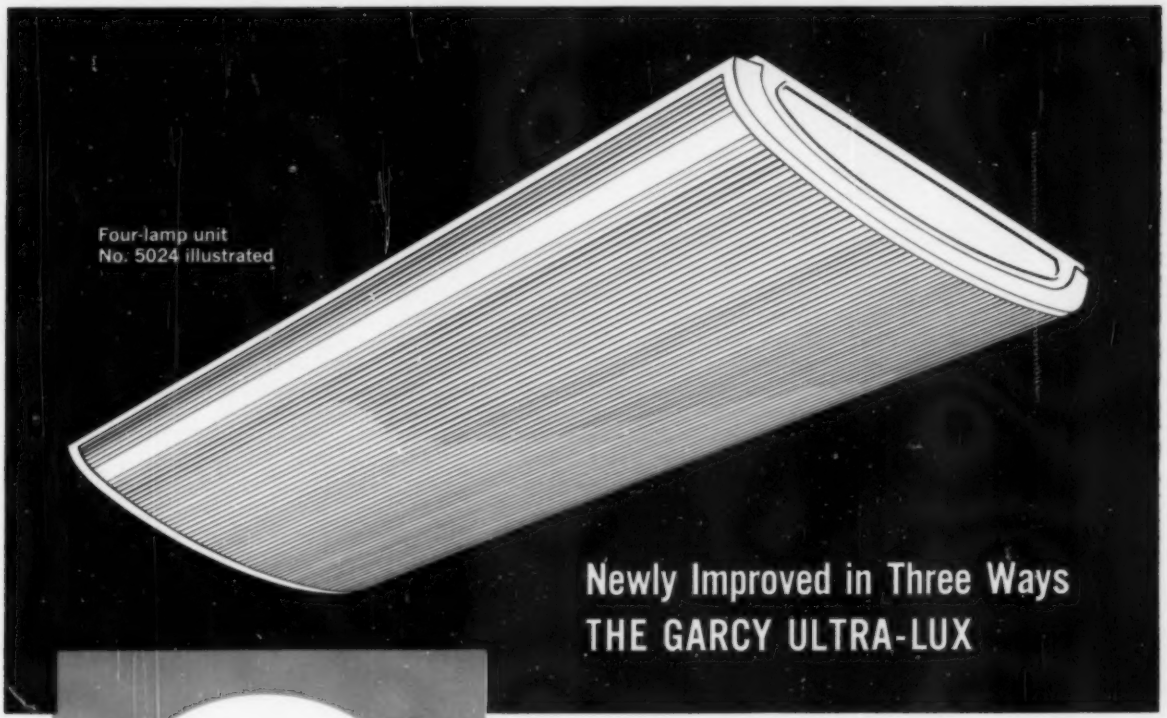
ANNOUNCING COLD-ROLLED ALUMINUM MONOTUBE POLES

Contact Union Metal for details regarding cold-rolled poles of strain hardening, aluminum alloys.

THE UNION METAL MANUFACTURING CO.

Monotube Engineered Poles

Canton 5, Ohio • Brampton, Ontario



Newly Improved in Three Ways
THE GARCY ULTRA-LUX

Owens-Corning Fiberglas . . .
exclusively available in
curved panel for Ultra-Lux
Soft white diffusers in
choice of polystyrene or acrylic

- **New Fiberglas diffuser**
- **New uniformity of brightness**
- **New and distinctive styling**

NEW CHOICE OF DIFFUSERS. A Garcy first . . . Owens-Corning's polarizing Fiberglas in a curved panel. In milk-white diffusers, our Koppers Even-Glo polystyrene and Plexiglas acrylic are the finest available.

NEW SURFACE BRIGHTNESS CONTROL. A slight alteration in the relationship of the diffuser to the lamps has completely eliminated shadows and lamp images, resulting in uniformly soft surface brightness across the entire panel.

NEW STYLING. The shallow, ceiling-hugging design that gives Ultra-Lux its "built-in look" is unchanged but the end has been re-styled for a cleaner, trimmer appearance.

The Ultra-Lux is available 12" wide (two-lamp 4 ft. or 8 ft.) and 24" wide (four-lamp 4 ft.) as shown above.

Send for newly published Bulletin 60-C

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Div. of Garden City Plating & Mfg. Co.
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Kopp Lighting Glassware

LENSES . . . COLOR FILTERS . . . COVER GLASSES

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Flat fresnels for interior lighting

Lighting lenses for beam control

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Lenses for interior or exterior aircraft lights

Lenses and color filters for airport runway lights

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Railroad signaling lenses

Ultraviolet and Infrared glasses

Heat-resisting and, or tempered glasses

KOPP GLASS

Designed to meet your precise requirements in lighting distribution, color transmission, etc.

You can frequently save time and money by consulting with Kopp engineers before your design specifications are finalized. We may be able to reduce costs by suggesting changes in size, shape, dimensional tolerances, or composition and still give you the performance you want.

Write or call us *today* about your problem. In over 50 years, Kopp Glass has designed and custom-produced a wide variety of products to solve special lighting problems. Typical examples are given on the right.

Kopp's team of engineers and glass technologists are fully qualified to review your individual application, develop the composition of the glass, design the molds, and establish manufacturing procedures for the product you need. The result will be accurate and lasting colors, proper light transmission and distribution, controlled physical characteristics—in fact, the exact combination of properties that best meets your requirements.

Ask for copy of new brochure "This is Kopp Glass"

Kopp Glass, INC.

Swissvale, Pennsylvania

New Aluminum Troffers for POWER-GROOVE . . .

COMFORTABLE, High Footcandle Lighting at LOWER COST than Ever Before Possible

SINGLE ALUMINUM TROFFER

TWIN ALUMINUM TROFFER

Another Lighting First . . . Miller has just broken through some long standing cost barriers to COMFORTABLE, high footcandle lighting for Offices, Stores, and Public Buildings. Now, you can obtain or provide today's needed higher levels of light at *much* lower cost.

For Example . . . The lighting installation pictured is designed to maintain 120 footcandles in this 60′ x 80′ general office area. Fixtures are Miller's new Twin Aluminum Troffers—2′ x 8′ units with Power Groove Lamps. Compared with conventional, 2′ x 4′ door type recessed systems using 40w Rapid Start Lamps, and providing comparable footcandles and comfort: this new Power Groove system *requires only ¼ as many fixtures,* and *has an initial installed cost 30%-38% lower. Annual Owning and Operating cost figures 14%-18% less.* And, fewer fixtures needed means a less cluttered, more pleasing ceiling appearance. Here, 34% more ceiling area is available for acoustical treatments.

Substantial savings can be realized for both relighting and new construction . . . wherever comfortable, high footcandle lighting is desired. Let us prove to you how such savings are possible for this and other typical installations. Simply *fill out and mail the coupon.* Or, contact your Miller Representative.

MAIL TODAY

To: Dept. A-260
THE MILLER COMPANY, Meriden, Conn.

☐ I'd like additional information on how I can obtain comfortable, high footcandle lighting at lower cost with Miller Aluminum Troffers.

☐ Have Your Field Representative contact me.

Name_____ Position_____

Company_____

Street_____

City_____ State_____

LIGHTING BY
miller
SINCE 1844

eye-fi RE/LIGHTING

THE miller COMPANY
MERIDEN, CONNECTICUT

The nearsighted MISTER MAGOO says... "1954? A significant year for the Magoo exchequer. I cannily invested in a galaxy of uranium stocks, and General Electric invented the Quartz Infrared Lamp. Happy birthday, Quartz Infrared! Confound it—they put two fuses on these new-fangled firecrackers and neither one works!"

INSTANT HEAT!

G-E tubular Quartz Infra-red Lamp hits 4,000°F. in less than a second

. . . and two seconds after your customer turns off this pencil-thin lamp, 80% of its radiant energy is gone. Residual heat won't overheat his product.

Pour a glass of ice water over this lamp at full heat and — nothing happens! The quartz tube withstands violent temperature shock.

General Electric's tubular Quartz Infrared Lamps are made for jobs where high or low amounts of concentrated radiation are needed *fast*. Examples: cooking food; shaping plastics; drying paints, paper, inks and glue; heating people; testing aircraft at supersonic-flight temperatures.

In most cases, you'll be surprised how few lamps do the trick. You can produce concentrations of 10 to more than 10,000 watts per square foot. It's the most powerful infrared source of its size. Quartz Infrared Lamps are simply constructed with a flexible wire at each end and can be installed economically. They've been proved in actual use for over six years.

Choose the exact size — 500 to 5000 watts — in 5″ to 50″ lengths at 100 watts per inch. Ask your General Electric lamp representative for information on how Quartz Infrared Lamps can help your customers. General Electric Co., Large Lamp Dept. C-11, Nela Park, Cleveland 12, Ohio.

Progress Is Our Most Important Product

GENERAL ELECTRIC

ABOVE ALL:

Styrene lighting louvers molded of

LUSTREX® PERMA TONE

55° Louvers of Lustrex perma tone by American Louver Company, Chicago, Illinois, in the IBM Datacenter, Chicago, Illinois.

Here's why Lustrex perma tone is the most popular ultraviolet light-stabilized styrene today.

You can create large areas of illumination with uniform light distribution, and good diffusion, that are strikingly handsome yet low in cost. Lustrex perma tone—exceeding IES-NEMA-SPI joint specifications for ultraviolet light-stabilized styrene—assures truly translucent whites, and a complete range of colors. It is light in weight for easy handling, installation and maintenance—and it is dimensionally stable.

New Impact Lustrex perma tone provides extra toughness and flexibility for snap-fitting to metal parts, high resistance to abnormal abuse, and lighter weight through thinner walls. Write for comprehensive technical report on both types of perma tone, including accelerated aging test results and other valuable data on styrene in lighting, to Monsanto Chemical Company, Plastics Division, Room 801, Springfield 2, Mass.

Monsanto®

LUSTREX: Reg. U. S. Pat. Off.

MONSANTO INNOVATOR IN **PLASTICS**

{OOOH look at that mess!

. . . and it's so unnecessary
since Jefferson announced
DRI-LOK

the ballast
that can't
drip compound

Gone forever is the danger of messy compound leakage. In the new Jefferson DRI-LOK ballast, conventional compound has been replaced by a newly developed thermo-setting material. This dry, solid-fill material is so physically and chemically stable it cannot soften or liquefy, cannot combine or react with any other material in the ballast. It fills the *entire* case and *permanently* bonds case, core and coil into one solid, voidless unit.

The New DRI-LOK Ballast is Engineered to Meet Newly Proposed CBM Higher Light Output Standards

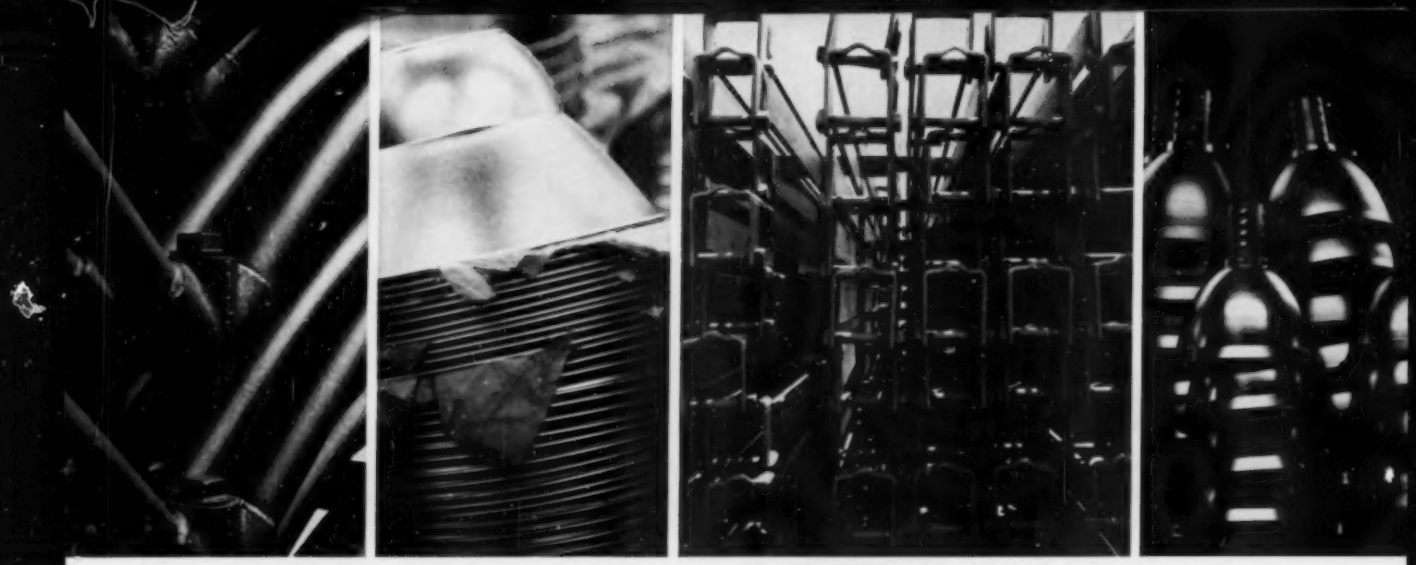
Write today for complete details and specifications.

NOW IN PRODUCTION

Jefferson DRI-LOK

New Blue FLUORESCENT BALLASTS

JEFFERSON ELECTRIC COMPANY • BELLWOOD, ILLINOIS



Large-scale production in Revere plant plus large inventory of all standard poles, reflectors, fittings and accessories assures prompt availability to fill any demand. Our excellent facilities also permit fast service on special orders for modified or custom-engineered outdoor lighting equipment, available in production quantities for volume users.

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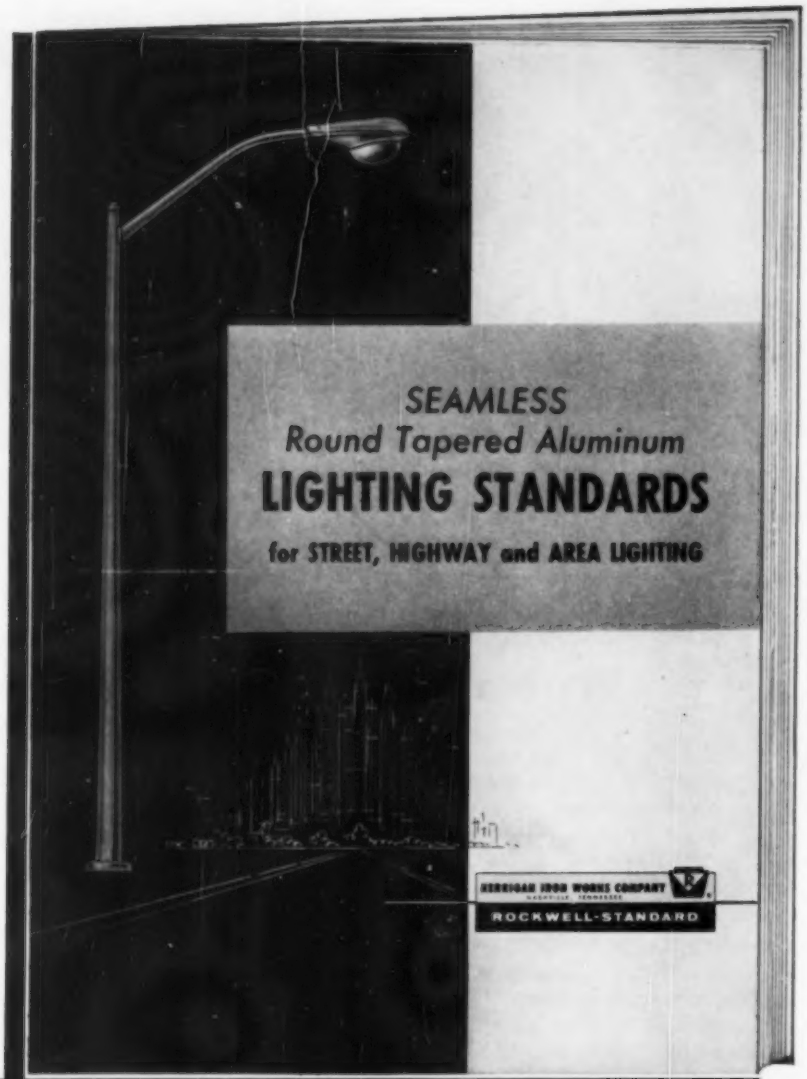

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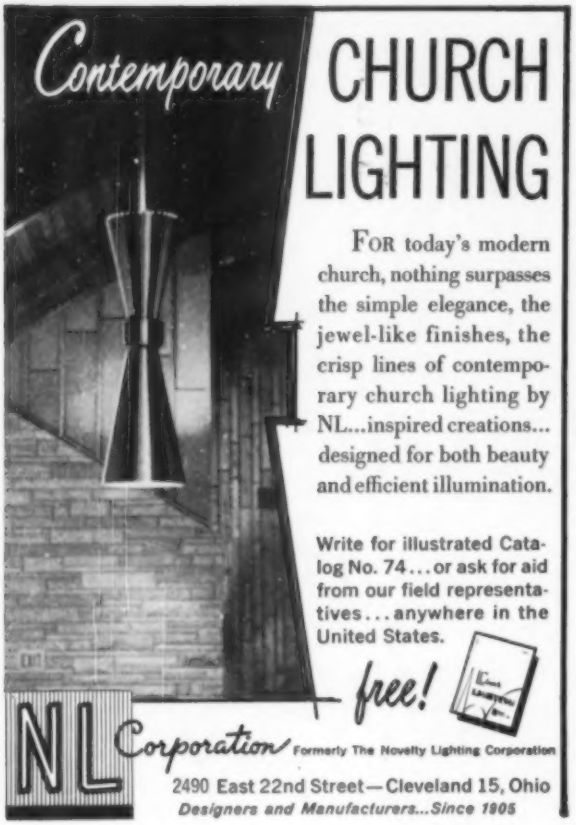
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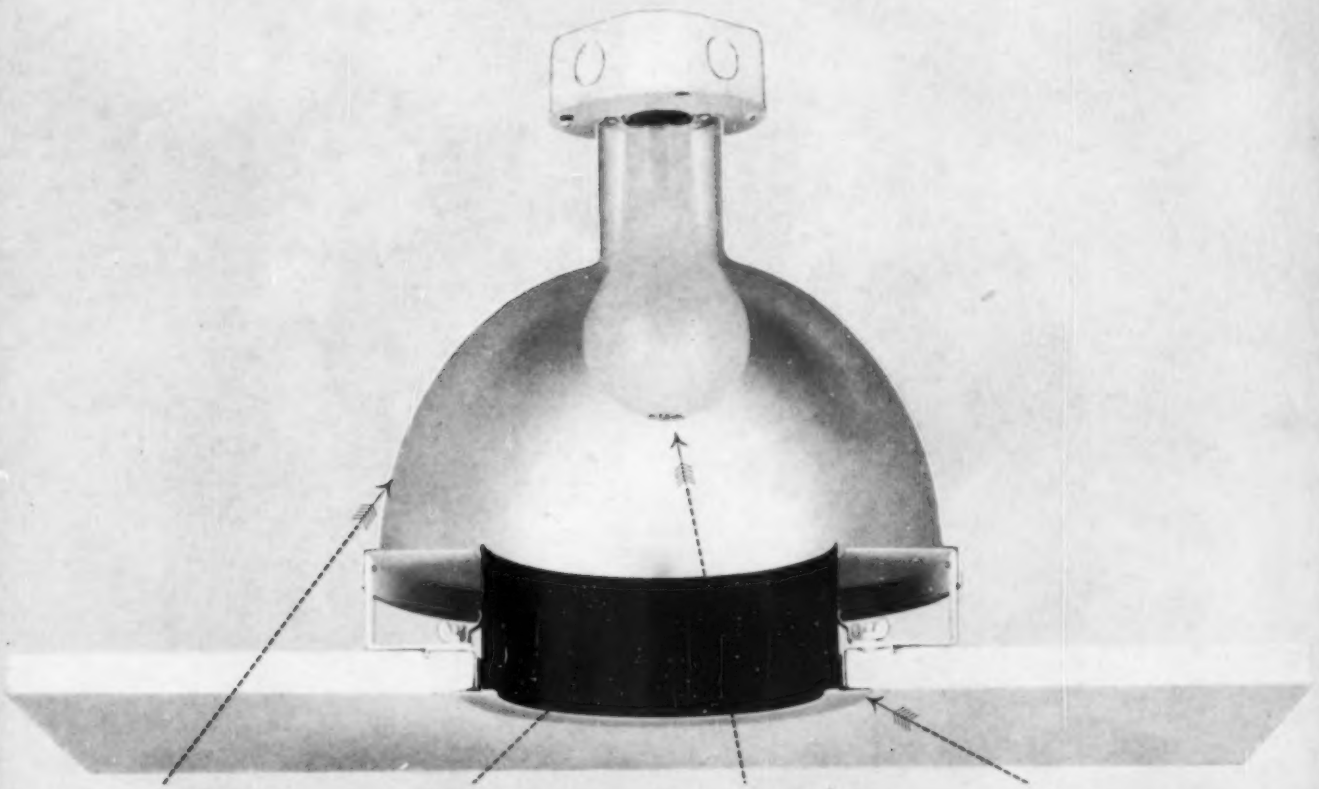

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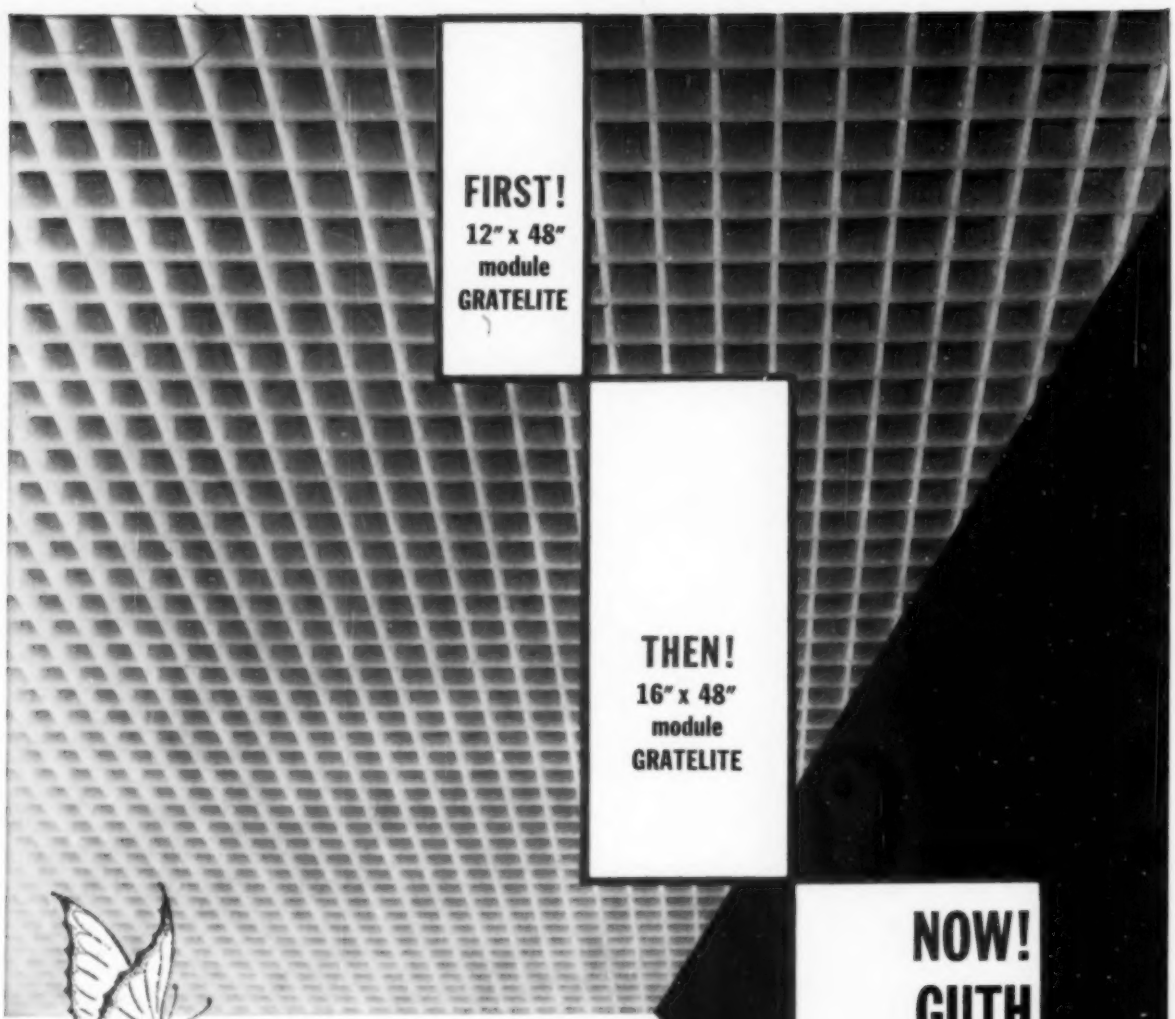
816	150W. A23 I.F.	5¼"	PLASTER
822	200/300W. PS30 I.F.	6"	DRY
832	200/300 W. PS30 I.F.	6"	PLASTER



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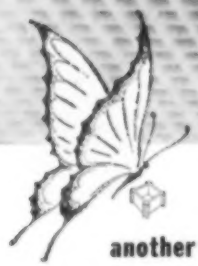

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